POWER

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The Advertising Pages

I SENT out a lot of letters—perhaps you received one of them—asking how *Power* could be made more interesting and useful.

Almost everybody told us we were going great already.

Some offered suggestions by which we hope all will profit.

One says:

> Cut out some of the Ads and put in some more practical dope, and you will have a real book on *Power!*

It costs between $25 and $30 to send *Power* to a man for a year.

And we get $2 or $3 for it.

It is the advertiser who makes it possible for the subscriber to get the paper for little more per issue than he pays for his daily paper.

And to the live, up-to-date engineer, the advertising pages are of hardly less interest and value than those of the reading section. Many of the answers to our letter attest to this fact. See the one on the Ad. Editor's page.

If you are a sportsman, you know with what a keen interest you go through the advertisements in your sporting paper to see what is new in arms and tackle and camp accouterment. If you own a car, you know how you scan the advertisements of automobile accessories. If you are a golfer, a gardener, a boatman, whatever is your interest and your hobby, you will look for food for it in the advertisements of its class paper.

How is the busy "running engineer" to become well informed? How is he to get knowledge of apparatus other than that which he or his immediate friends and neighbors are running?

When the question comes up in his engineering society or in discussions with his fellows or as an inquiry from his employer, "What about so-and-so for use in such-and-such circumstances?" the fellow that will shine is the one that knows.

And when one gets the habit of knowing and of shining—well, he just naturally stands out ahead of the rest and gets remembered when some job is looking for a man of the better sort.

If your employer gets a bright, intelligent answer, demonstrating real knowledge of the subject, he will be satisfied and pleasantly impressed, and will turn your way again when he wants to know something in your line.

You can get this kind of information out of the advertising pages and out of the books and catalogs that the advertisers want to send you.

Don't cuss that advertising! It is paying more than its own share of the freight.

Look over a few pages of it carefully. Ask yourself how complete your knowledge is of the matters treated and whether you had not better do some thinking and studying about them. The advertiser will be glad to help you.

Did you ever look over the advertisements of an old magazine—fifteen or twenty years old?

How logical and natural has been the development since that time! The changes and adaptation have followed such obvious lines that it would seem that one versed in the art could have predicted or indicated them.

All is not yet. There are new discoveries to be made, new devices to be invented, new adaptations of apparatus now in their beginnings. Get into the game. You can at least know and understand what there is and as it is—and you may find something better.

F. R. Low

Rebuilding Boiler Plant Reduces Coal Consumption over One-Half

A MODERN boiler plant containing six water-tube boilers varying in size from 4,000 to 5,000 square feet of heating surface was built on the site of an old overloaded plant containing fifteen boilers, without interruption to service. It was found that eight of the old boilers were in good condition, and these were rebuilt and enlarged by placing another deck of tubes below the old ones and connecting the headers by short nipples. Purchasing two new boilers made available ten, six of which have been installed, and room left in the plant for installation of the remainder when they are needed in the future when the load increases.

WHEN building a new power station, the designing and construction engineers can choose the arrangement of equipment and erection methods that best meet their needs. In so far as the actual construction is concerned, no very unusual problems are generally involved. It is simply a case of beginning at the ground and building up, with few other considerations than to get the equipment in place in the easiest and most satisfactory way. To rebuild an old overloaded plant into a modern efficient station and continue to give twenty-four hour service to a large manufacturing plant requires power-plant construction engineering skill of the highest quality. When this work is carried on by the operating engineers of the plant, as was done in the construction of the new boiler plant of the Keasbey & Mattison Co., Ambler, Pa., manufacturer of magnesia and asbestos products, it is an accomplishment of which they may be justly proud.

In 1919 this company's requirements for steam to supply process work and power purposes equaled the maximum capacity of the boiler plant, which had then reached demands where about 50,000 tons of coal were burned per year. This boiler plant, like many others throughout the country, had just grown to meet the needs of a rapidly growing industry and like most of such plants grew along lines that are not conducive to efficient operation, and had a number of small boilers improperly set, with inadequate means for handling coal and ashes and lacking equipment for obtaining proper records of operation.

Something had to be done to obtain more capacity, and the old plant had been extended about as far as possible without erecting another stack and rearranging the coal handling equipment. This would have made the extension expensive, the inefficient operating condition would have still existed and only temporary relief as to capacity would have been obtained. An engineering study of rebuilding the old plant showed that practically three times the boiler capacity could be put in a building occupying little more ground area than the old plant, and this would have proved sufficient well into the future. The cost of rebuilding the plant compared with that for an extension that would give added capacity equal to the old plant made the rebuilding proposition by far the more desirable. Furthermore, the improvement in operating efficiency would, it was calculated, cut the coal consumption practically in half for the same steam production, and a reduction in labor of from 50 to 75 per cent would result. All these considerations led to a decision in favor of a new plant.

A new plant might have been constructed on another site, but the old one had two good stacks, one a brick and the other a self-supporting steel, each 200 ft. high, the former 9 ft. and the latter 8½ ft. inside diameter at the top, therefore it was desirable to use these and save the cost of new ones, especially as the installation of forced-draft fans would give them sufficient capacity for the new plant. The old plant was also ideally located to receive coal by rail and provide convenient coal-storage facilities. Therefore it was decided to build the new plant on the site of the old one and keep all the old boilers in service until some of them could be replaced by new ones.

In the boiler room there were 15 water-tube boilers, stoker-fired but not equipped with forced draft, and they could scarcely be operated at rating. Six were of a very old type and each contained 3,500 sq.ft. of heating surface. There were 9 B. & W. longitudinal-drum inclined-tube boilers, two of which contained 4,000 sq.ft. of heating surface and 7 each of 3,000 sq.ft. All boilers operated at 110 lb. gage pressure, without superheaters or economizers.

All the boilers were set on grade with only about six feet between their rear and the boiler-room wall, with about the same distance between the front of the stokers and wall. Whenever a tube had to be replaced, it was necessary to knock a hole in the building wall to get the old one out and the new one in. There was not sufficient room back of the boilers for the breechings, so they were located over the firing aisle and connections brought from the rear of the boilers up over the top into the breeching. In Fig. 1 the breeching and connections to the boilers can be seen over the firing aisle. The stacks were on foundations outside the boiler house in front of the old boilers. Therefore gas travel was up from the rear over the tops of the boilers to the breeching located over the firing aisle and to the stacks outside the building. The steam header was also over the boilers.

Coal for the old plant was received in cars on an elevated track and dumped into a track hopper, whence it was delivered into a car pushed by hand through a tunnel to an elevator shown at the right in Fig. 6, and hoisted to the top of a coal tower and dumped into another hopper. From here it was fed to a crusher and delivered to another car on a track in the boiler room which ran on a level with the top of the stoker hoppers. The location of the coal tracks can be seen just above the front of the furnace in Fig. 1. With this arrangement no coal storage in the plant was available, and if the elevator were to fail for any length of time it would have been a difficult matter to coal the boilers. The old boilers being set on grade and the amount of space in the firing aisle being limited, it was necessary to remove the ashes from under the boilers through a tunnel by

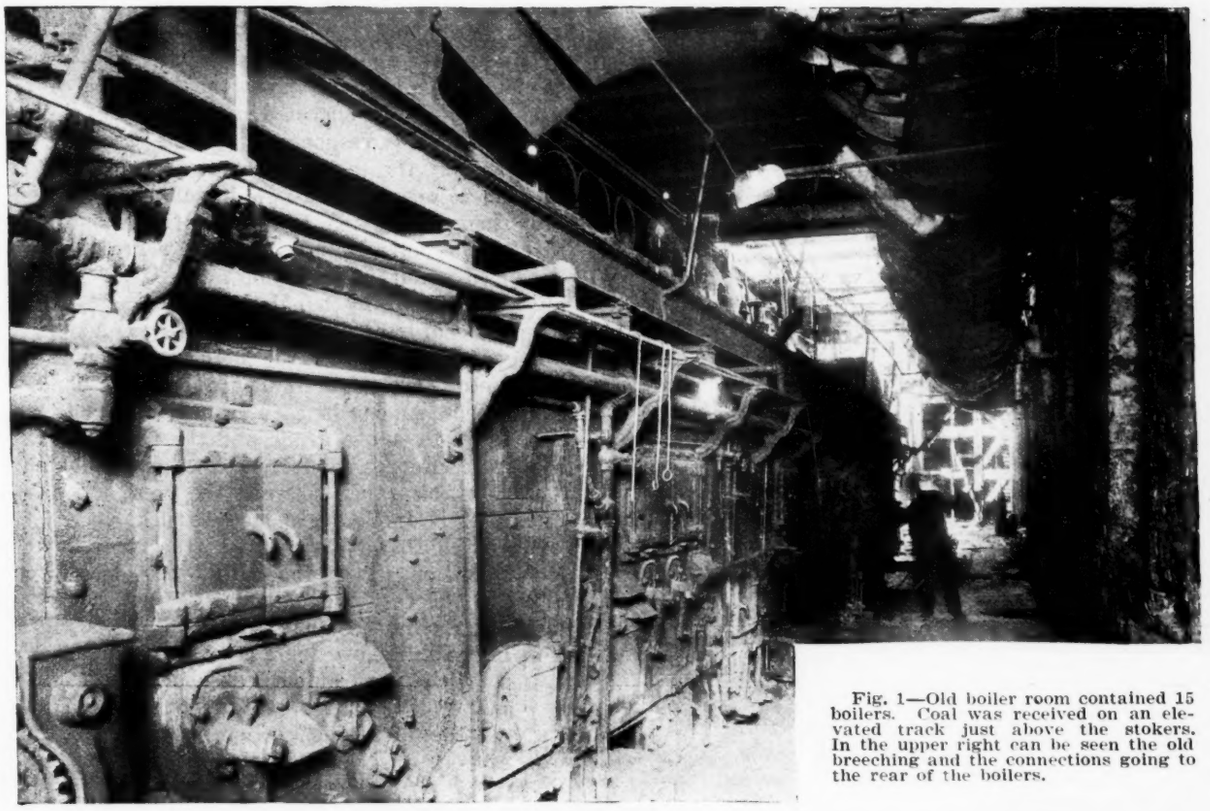


Fig. 1—Old boiler room contained 15 boilers. Coal was received on an elevated track just above the stokers. In the upper right can be seen the old breeching and the connections going to the rear of the boilers.

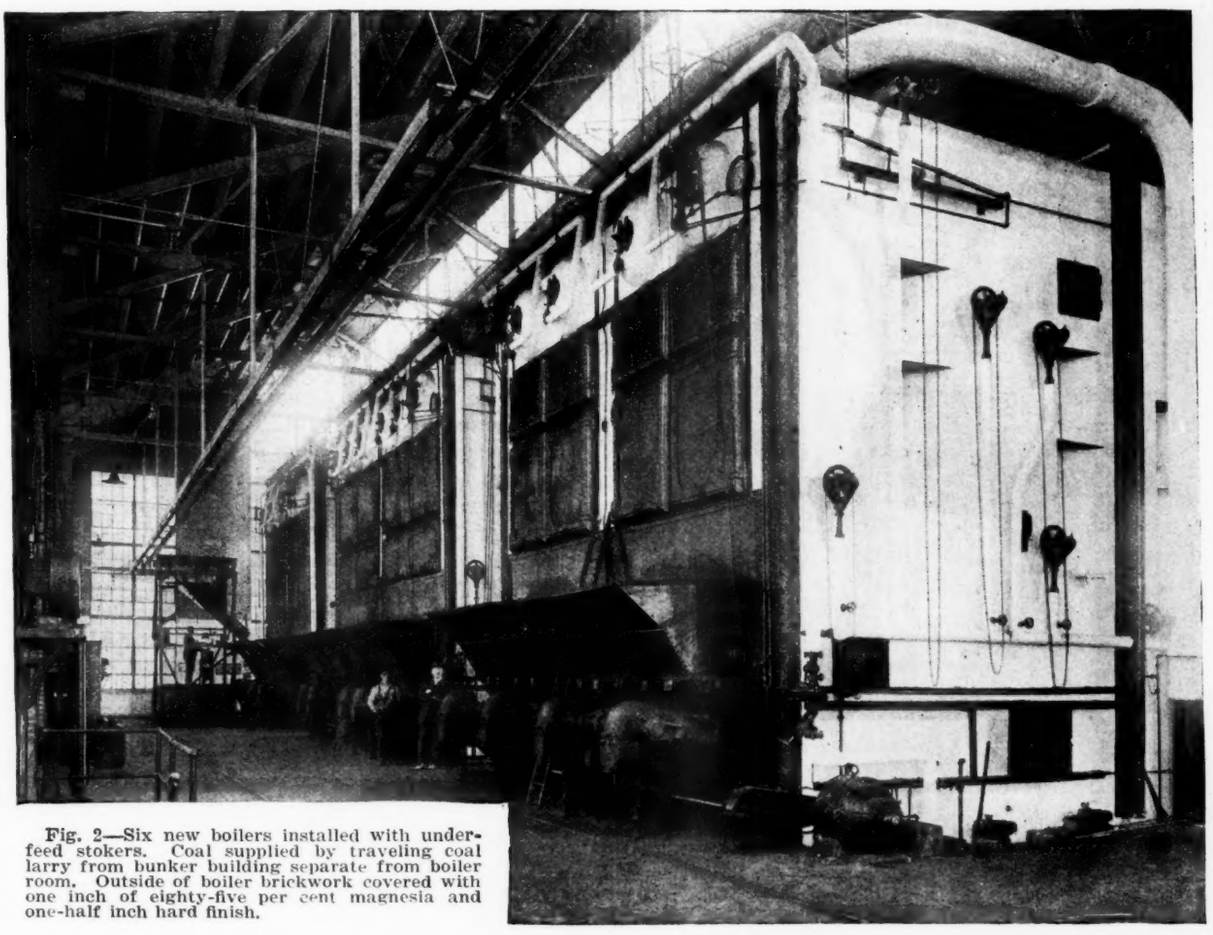
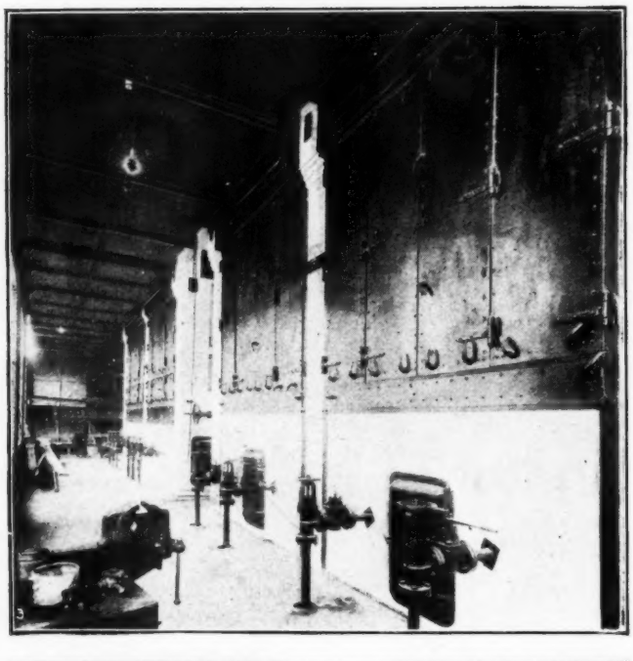
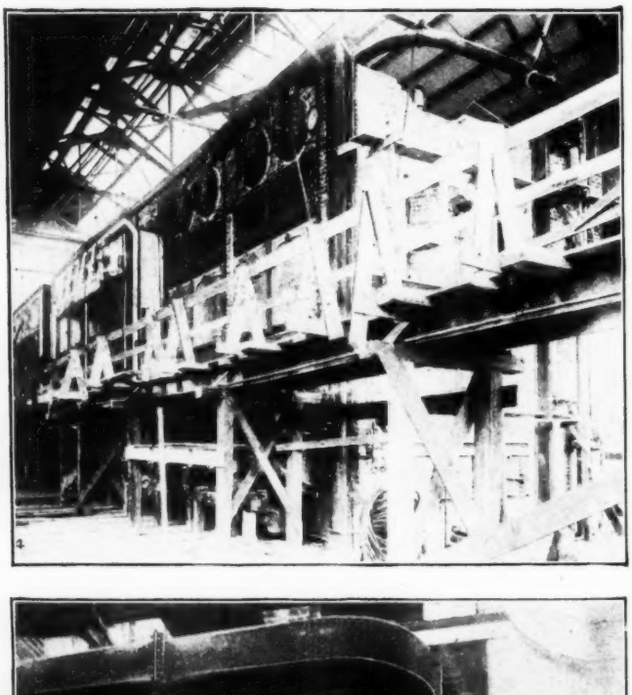
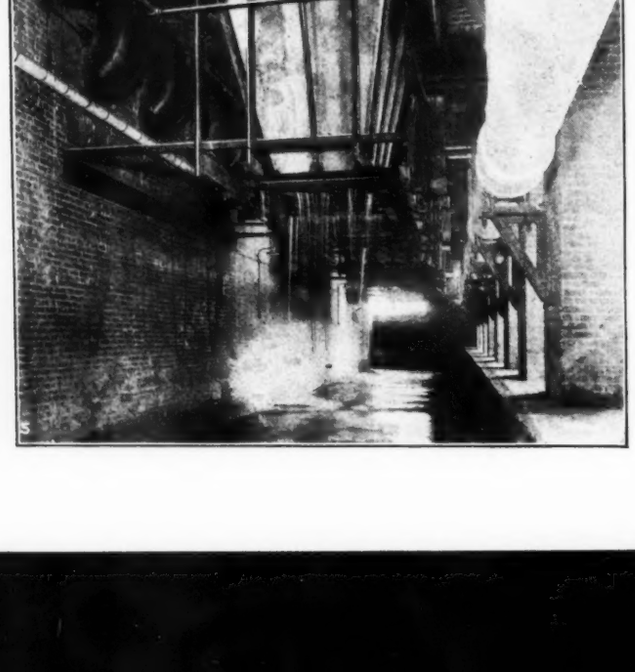


Fig. 2—Six new boilers installed with underfeed stokers. Coal supplied by traveling coal larry from bunker building separate from boiler room. Outside of boiler brickwork covered with one inch of eighty-five per cent magnesia and one-half inch hard finish.







hand-operated cars. These cars were pushed to the coal elevator and raised high enough to dump into an elevated ash bin.

These were the conditions that existed when it was decided to build a new plant that could be conveniently and economically operated on the site of the old one. How well those responsible for the work succeeded is indicated by the fact that where the old plant required 32 men to operate, the new installation is attended by 7 on the three shifts. In the old plant about 50,000 tons of coal was burned per year; last year the new boilers produced about 20 per cent more steam than the old ones and did it by burning 27,795 tons. In the new plant all coal is handled by machinery and the ashes are dumped directly from the hoppers under the stokers into motor trucks, so that practically all hand work is eliminated. As can be seen from Fig. 9, the firing-aisle floor is 13 ft. above grade and the floor under the ash hoppers is depressed 6 ft. below grade, which leaves 9 ft. 6 in. clearance between the floor and ash-hopper gates and is ample for a motor truck.

Since the B. & W. boilers in the old plant were in good condition, it was found that considerable could be saved in the cost over purchasing new boilers by enlarging the old ones. This was done by placing another deck of tubes below the old one and connecting the headers with short nipples, as shown in Fig. 9. The two 4,000-sq.ft. boilers were rebuilt of 5,090 sq.ft. and 6 of the 3,000-sq.ft. boilers were rebuilt for 4,000 sq.ft. and one old B. & W. boiler was scrapped.

Starting To Rebuild the Plant

When starting to rebuild the plant, it was necessary to keep all the old boilers in operation until some new capacity was available to take some of the load and allow removing some of the old boilers. To take care of this, it was decided to purchase two new boilers complete with underfeed stokers and forced-draft fans. These boilers have 4,540 sq.ft. of heating surface.

In constructing the building for the new plant, the west wall was built complete about 20 ft. away from the wall of the old plant. The new north wall was located about 10 ft. away from the old, but the east wall on account of the stacks had to be constructed directly on a line with the old wall, so that this wall had to be removed and new foundation put down before the new one could be built. In the first step about 50 ft. of the east wall was taken down and replaced by a new one, and this section of the new plant roofed over. This allowed removing part of the old building under the new roof. The 10-ft. space gained in the new plant plus that between the end boiler and the north wall of the old plant provided room for installing the first two new boilers. The new boilers were installed facing the opposite of the old one with their rear about ten feet away from the wall. This was done so as to build the new breeching back of the boilers opposite the smoke connections. This arrangement can be seen from Figs.

BOILER ROOM DURING CONSTRUCTION AND AFTER COMPLETION

Fig. 3—A clear well-lighted working space of 10 ft. is provided back of the boilers, with the breeching located over head.

Fig. 4—New boilers were coaled temporarily during reconstruction by hand-operated cars run on an elevated track, level with the stoker hopper.

Fig. 5—Ashes are dumped from the stokers into concrete hoppers and from here are hauled away in motor trucks. Connections between the forced-draft duct and stoker windboxes are shown at upper left.

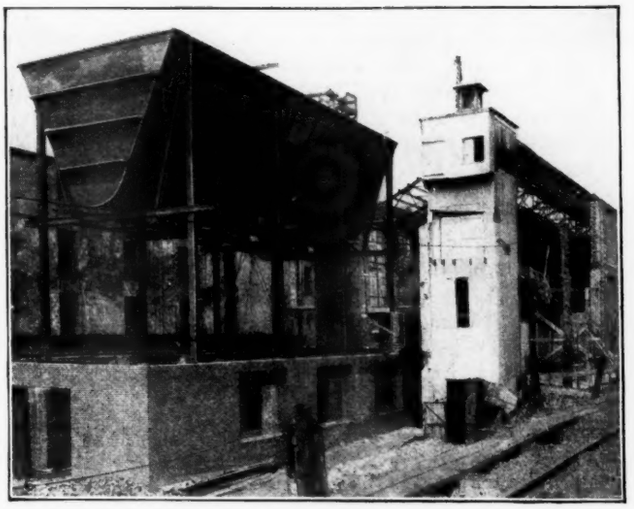
3 and 9. These two boilers were installed as a battery with their reinforced-concrete ash hoppers and connected permanently to the new breeching, steam header and forced-draft-fan duct, the latter being installed below the firing aisle and connected to the windbox of the stokers by short right-angled bends passing through the wall of the ash driveway, as may be seen in the upper left-hand corner, Fig. 5. Temporary arrangements had to be made for removing the ashes from the new boilers with the old equipment, and the new breeching and steam header were connected temporarily into the old ones. The new steam header is placed below the boilers in the ash driveway. It is supported on roller brackets, is anchored in the center and runs the entire length of the boiler room without a bend or expansion joint. Steam connections between the boilers and the header come from over the former and down directly through the floor to the latter. The length and shape of the connections are considered sufficient to take care of any movement of the header due to expansion and contraction.

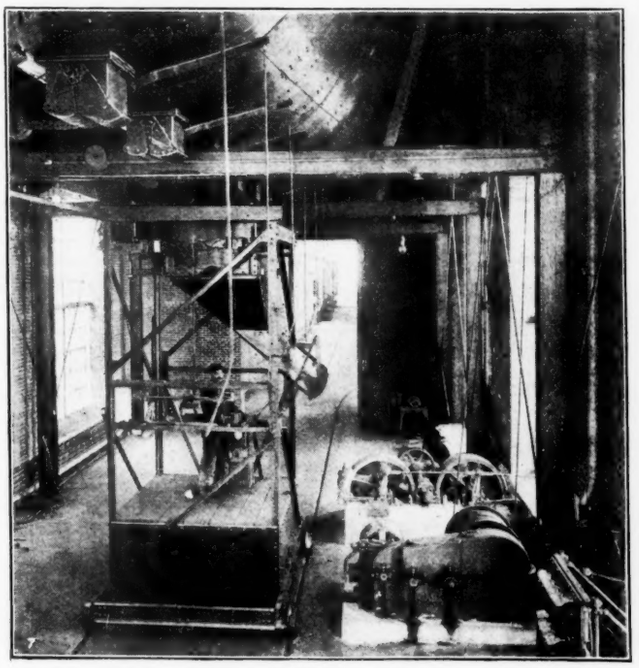
Temporary Coal-Handling Equipment

A temporary coal track, Fig. 4, was put in on a level with the hoppers of the new stokers and this track carried over the old boilers into the old coal tower, Fig 6. This was used to coal all the new boilers until the new coal-handling equipment could be installed. When the first two new boilers were put into service, they allowed taking out two old ones, which permitted reaching one of the stacks with the new breeching. These two boilers were rebuilt and installed similar to the two new ones. The breeching was constructed and hung from the roof trusses, and on Sunday when everything was ready the old breeching was taken out and the new one put in and the second pair of new boilers connected into the new steam header and forced-draft equipment. This gave four new boilers completed, with permanent connections, and forcing these units allowed taking out the six old boilers that were to be scrapped and two other boilers that were to be rebuilt. After the boilers were removed, the new building was completed and the two rebuilt boilers installed. This gives six boilers installed, five of which are sufficient to carry the loads, leaving one as a spare for cleaning. There is space in the plant for installing four more boilers of the same capacity as those in operation. Four additional rebuilt boilers are in plant and will be erected as soon as they are needed.

All the new boilers are equipped with underfeed stokers driven by variable-speed direct-current motors. The stokers and forced-draft equipment have sufficient capacity to operate the boilers at 200 per cent rating. On the two 5,090-sq.ft. boilers the stokers have a grate area of 114.5 sq.ft., and on the others a grate area of 87.5 sq.ft. is provided.

In the old plant the condensate from the processes returned to an open hotwell in a building adjacent to the boiler house, from where it was pumped to the





COAL BUNKER LOCATED IN BUILDING ADJOINING BOILER ROOM

Fig. 6—Coal bunker of 600-tons capacity supported on eight steel columns before building was completed. Old coal tower is shown on the right.

Fig. 7—Coal-hoisting and drag-scraper machinery is located on second floor of bunker building.

Fig. 8—Skip-hoist delivers coal to bunker from crusher located under elevated coal track on the right. When the bunker is full, crushed coal is returned to storage yard along track, from where it can be reclaimed by a drag scraper.

heaters and then to the boilers. In the new plant all the feed-water equipment is in a room in the boiler-house basement. The condensate from the processes returns to two large steel tanks located at a level so that the return flow is by gravity. The makeup feed water also flows into these tanks, the level being maintained by float valves. From these tanks the water is pumped into closed-type heaters and to the boilers, which are equipped with feed-water regulators. Feed water to the boilers is measured with a recording and integrating flow meter, and each boiler is equipped with a draft gage, a CO_2 recorder and a temperature gage indicating the temperature of the gases as they leave the boiler, and the steam delivered by each boiler is obtained on a combination recording and integrating flow meter. The forced-draft fans discharge into a common header, and the draft to the boiler is controlled by automatic regulators.

All exposed heated surfaces of this installation are insulated and protected from heat losses in the most approved manner. The piping is all covered with 85 per cent magnesia covering, double-standard thickness, installed according to the broken-joint method of application. The brick walls of the boiler settings are covered with one inch of 85 per cent magnesia applied with a trowel, and over this is one-half inch of hard asbestos finishing cement containing 75 per cent of short asbestos fiber. This, when dry, makes a hard smooth finish and effectually seals any cracks that might have appeared in the brickwork. Some of the boilers

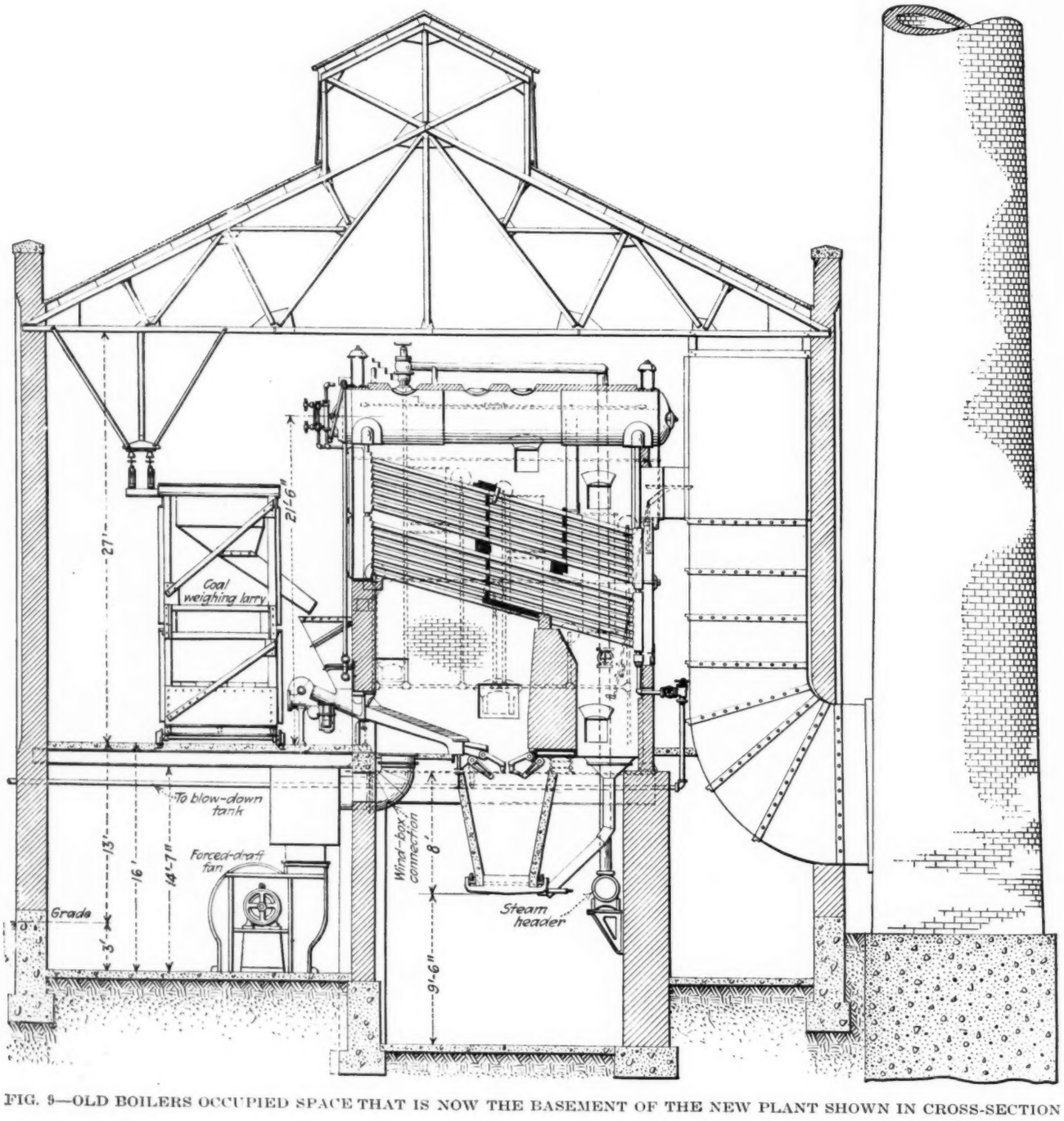


FIG. 9—OLD BOILERS OCCUPIED SPACE THAT IS NOW THE BASEMENT OF THE NEW PLANT SHOWN IN CROSS-SECTION

have been in service for over a year and have operated at over 175 per cent rating without any difficulty with the furnace brickwork.

On top of the boilers are laid standard blocks of magnesia, four inches in thickness, upon which is floated one inch of magnesia plastic. When this top coat had dried out, all the cracks were filled in with additional magnesia plastic material.

Coal Bunker Located in Building Separate from Boiler House

A feature that is rather unusual is the location of the coal bunker separate from the plant. Although this practice is not absolutely new, it is an exception and not the rule. The breechings from the boilers are carried horizontally to a point opposite the stacks and then dip down so that their center line is about on a level with the firing-aisle floor and go into the stacks. This was made necessary on account of the location of the connections for the old boilers. These two breeching connections in the center of the boiler room leave about 30 ft. unoccupied by boilers, and if an overhead bunker had been installed, it would have been excessively long if run the entire length of the boiler room. Placing the bunker overhead would have required not only a much higher building but also more expensive construction. Those responsible for the design of the plant wanted it well lighted and a minimum amount of dirt and dust from the coal.

One has only to look at Figs. 2 and 3 to know that the boiler room is about as pleasing a place to work in as most engine rooms. On account of the coal tracks being on the same side of the plant as the stacks and the opposite side from the firing aisle, the coal-elevating equipment could not have been conveniently located without extending the boiler house. About the time the question of the coal-handling equipment was being considered, the opportunity presented itself for the purchase of a new 600-ton bunker at a very low cost, a "left-over" from one of the war-baby industrial plants. By using the short bunker and the type of coal-elevating equipment selected, all horizontal coal-distributing equipment was eliminated and this not only reduced the cost but also simplified the equipment.

DATA ON MECHANICAL EQUIPMENT KEASBEY & MATTISON COMPANY'S BOILER PLANT AMBLER, PA.

GENERAL

Plant location	Ambler, Pa.
Boilers installed	6
Boilers installed, ultimate	10
Boiler-feed and service pumps, turbine driven, all other auxiliaries, motor driven	
Nature of load served	Manufacturing magnesia and asbestos products
Length of boiler room inside	245 ft. 10 in.
Width of boiler room, inside	49 ft. 10 in.
Distance from basement to boiler-room operating floor	16 ft.
Ratio of boiler-water heating surface to boiler house floor area (10 boilers)	3.7 to 1 in.
Width of firing aisle	20 ft.
Width of passage behind boilers	10 ft. 1 in.
Width of passage between boilers	8 ft.
Length of coal bunker building	77.8 ft.
Width of coal bunker building	31 ft. 10 in.
Distance from basement to boiler-room floor level	14 ft. 6 in.
Distance from boiler-room floor level to top of bunker	38 ft.
Distance from top of bunker to roof	12 ft. 3 in.

BOILERS

Manufacturer	Babcock & Wilcox
Type	Vertical header, inclined tube
Heating surface	Two-5,090 sq.ft., two-4,540 sq.ft. and two-4,000 sq.ft.
Grate area projected	Two-114.5 sq.ft. and four-87.5 sq.ft.
Boiler-heating surface per sq.ft. of grate area	two-44.5 sq.ft., two-51.5 sq.ft. and 45.5 sq.ft.
Working gage pressure, lb. per sq.in.	140
Superheat	None
Coal Analysis:	
Fixed carbon (dry basis)	74.69 per cent
Volatile hydrocarbons	16.46 per cent
Sulphur	0.80 per cent
Moisture	3.00 per cent
Ash	8.05 per cent
B.t.u. per lb. (dry fuel)	14,324
Height to center of steam drum above firing-aisle floor	21 ft. 6 in.
Height to bottom of front header from firing-aisle floor	10 ft. 10 in.
Combustion-furnace volume	two-1,250 cu.ft. and four-950 cu.ft.
Combustion-furnace volume per sq.ft. of grate area	11 cu.ft.

Boiler performance, taken from 24-hr. operation report	Lb. of Coal Fired Per Hour Per Cu.Ft. of Fur. Vol.
Boiler Rating, Per Cent	
100	1.35
150	1.92
175	2.33

Free area opening first pass, on largest boilers	25 sq.ft.
Free area opening second pass, on largest boilers	18 sq.ft.
Free area opening third pass, on largest boilers	16.5 sq.ft.

STOKERS

Manufacture	Westinghouse Elec. & Mfg. Co.
Type	Underfeed
Number of retorts	Two have 6 and four have 5
Stoker drive	Direct-current motor, adjustable-speed drum controller

Stoker performance, based on coal of 13,693 to 14,324 B.t.u. per pound. Data taken from 24-hr. operation report

Boiler Rating Per Cent	Combined Boiler and Furnace Efficiency Per Cent	Pounds Coal Per Retort Per Hour	Pounds Coal Per Sq.Ft. Grate Area Per Hour
110	70.3	310	17.8
150	75.0	400	23.0
175	73.6	485	27.8

Continuous capacity	200 per cent

FORCED-DRAFT FANS.

Manufacturer	Green Fuel Economizer Co.
Number installed	3
Speed	1,750 r.p.m.
Capacity, against 6-in. static head	23,000 cu.ft. per min.
Drive, direct, by 40-hp. Westinghouse alternating-current constant-speed motor	
Control	Mason regulators on fan dampers
Fan capacity per sq.ft. of grate area (three fans for 6 boilers)	119.9 cu.ft. per min.
Fan capacity per cu.ft. of furnace volume (three fans for 6 boilers)	10.9 cu.ft. per min.

STACKS

Number, two, one brick and one self-supporting steel	
Height above grate	200 ft.
Inside diameter at top, brick	9 ft.
Inside diameter at top, steel	8½ ft.
Area inside at top (two stacks)	120 sq.ft.
Ratio of chimney area to grate area (6 boilers)	1 to 4.8
Draft equipment capable of operating the boilers at 200 per cent rating, when burning bituminous coal, having a heat value of	13,500 B.t.u.
Breechings built by Cruse Kemper Co.	

FEED-WATER HEATERS

Number	2
Type	Closed
Manufacturers of one	H. S. B. W.- Cochrane Corp.
Capacity	120,000 lb. per hour
Manufacturer of one	Warren Webster & Co.
Capacity	60,000 lb. per hour

BOILER-FEED PUMPS

Number	3
Manufacturer of two	A. S. Cameron Steam Pump Works
Type, two	3 stage centrifugal
Speed	2,500 r.p.m.
Capacity	300 gal. per min.
Discharge head	580 ft.
Drive, direct-connected steam turbine	
Manufacturer	Terry Steam Turbine Co.
Manufacturers of one compound reciprocating 490-gal. per minute feed pump	Gardner Governor Co.

MISCELLANEOUS EQUIPMENT

Coal-handling equipment	R. H. Beaumont Co.
Traveling coal larry	R. H. Beaumont Co.
Coal bunker	R. H. Beaumont Co.
Soot blowers	Diamond Power Specialty Corp.
Automatic non-return valves	Crane Co.
Blowoff valves	Jos. F. Schiller
Gaskets	Keasbey & Mattison Co.
Feed-water regulators (Copes)	Northern Equipment Co.
Gate valves	Crane Co.
Reducing valves	Crane Co.
Traps	Fisher Governor Co.
Safety valves	Consolidated Safety Valve Co.
CO_2 recorder	Republic Flow Meters Co.
Pressure gages	Ashcroft Mfg. Co.
Pressure gages	Bristol Co.
Pressure gages	U. S. Gage Co.
Recording thermometer	Brown Instrument Co.
Stack temperature pyrometers	Brown Instrument Co.
Recording pressure gage	Bristol Co.
Steam and water flow meters	General Electric Co.

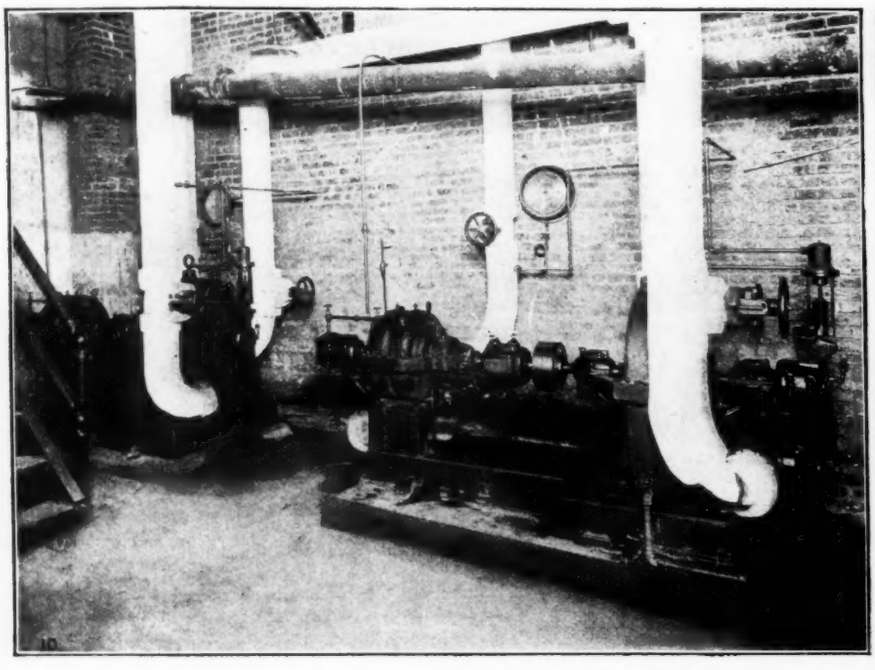
PIPING, ETC.

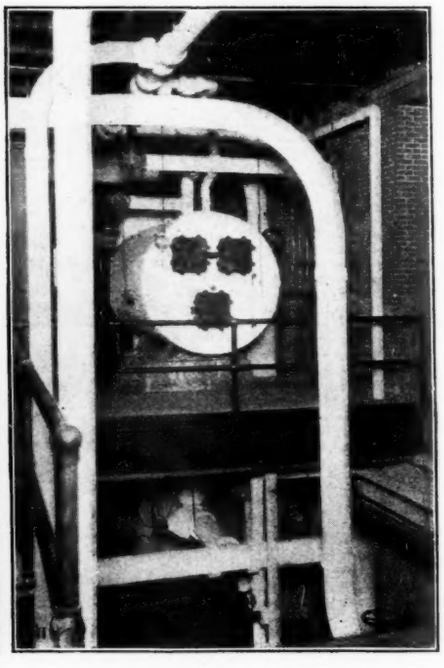
Piping	Furnished by Crane Co. All high-pressure piping, 6 in. and over, extra-heavy, with Vanstone joints and welded outlets. Feed-water lines extra-heavy, with Vanstone joints and steel fittings. Exhaust and low-pressure piping standard, screwed cast-iron flanges and fittings.
Pipe covering	Installed by Keasbey & Mattison Co. All high-pressure pipe covered with double thickness 85 per cent magnesia. All feed-water lines single thickness 85 per cent magnesia. Feed-water heater 1-in. blocks and ½ in. cement. Exhaust line double thickness air cell. A ½-in. air space is provided under blocks by means of expanded metal. Boiler brick work is covered on outside with 1 in. 85 per cent magnesia and ½ in. hard finish. On top of the boiler standard blocks of magnesia 4 in. thick are used covered with 1 in. plastic magnesia. All covering is whitewashed

A careful consideration of all these factors led to the adoption of a coal bunker in its own building, forming an extension to the boiler house, from where the coal is delivered to the stoker hoppers in a weighing larry. The bunker is supported on eight steel columns, Fig. 6, so that none of the weight is transmitted to the building walls. Below the bunker there are two floors, one of which is on grade and is used for a machine shop and pipefitting room. The second floor is on the firing-aisle level, and in addition to providing a runway for the coal larry it contains the coal-hoisting and drag-scraper machinery (see Fig. 7).

Coal is delivered on an elevated track running parallel with the boiler house and bunker building and is dumped into a track hopper, from which it goes through a crusher and to another hopper over the lower end of an automatic skip hoist. The hoist delivers the coal to a hopper over the bunker, and it is distributed by four spouts into the latter. When the bunker is full, crushed coal can be delivered to the storage pile, along the coal track by a fifth pipe leading from the hopper over the bunker. In the storage yard the coal is distributed by a drag scraper, which is also used to reclaim coal from storage. The storage yard, which runs along the coal track, has a capacity of about 10,000 tons, and all coal stored is crushed. The top of the hopper under the crusher is below grade level, which allows the drag scraper to deliver coal directly from storage into it and to the skip hoist. Since the machinery for operating the drag scraper is located on the second floor of the bunker building, the operator has a good view of the storage pile. Three men can unload and put into the coal bunker a 50-ton carload of coal in one hour. The coal track is equipped with a motor-operated nigger head, so that when a number of cars are delivered on the coal track, the first one may be unloaded and the others pulled to place for unloading. From the bunker a two-ton motor-operated weighing larry car delivers the coal to the stokers. This provides a means of obtaining a complete record of all coal going to the boilers and with a record of the steam and feed water a check can be made every twenty-four hours on the plant's operation.

What has been accomplished in the way of economy in the rebuilding of this plant is a fair example of what might be done in many others. Where plants have been rebuilt, it has generally been done in order to obtain more capacity, as in the foregoing case. There are many examples to show that from a monetary point of view it would have been economical to make the change long before it was necessary to do so on account of lack of capacity. In many industries the cost of power is a small item in the total cost of production, consequently as long as the old plant can give a fairly reliable service, those who hold the purse strings are inclined to feel that it is good enough, even though it may be uneconomical. However, the installation herein described, where it was possible to reduce the coal consumption by more than one half and the labor to about 25 per cent of that originally required, should show that the power plant may be made to earn a substantial dividend on the investment in modern equipment, when it is properly operated.





FIGS. 10 AND 11—TWO 3-STAGE TURBINE-DRIVEN FEED PUMPS AND ONE OF THE FEED-WATER HEATERS

The writer wishes to express his thanks and appreciation to Dr. R. V. Mattison, president, and R. H. Anderson, vice-president and superintendent, of the Keasbey & Mattison Co. for their assistance and co-operation in the preparation of this article.

De Laval and Rateau are generally given credit for being first in successfully commercializing the steam turbines. It is interesting to note that as early as 1836 steam turbines were built, sold and operated in the United States, some of which drove sawmills at Syracuse, N. Y. These were devised by William Avery, and were reaction wheels of the Hero type. The patent was issued in 1835 to Foster and Avery, being the first American turbine patent granted.

A Practical Way to Study Engine Performance

Outline of the Variations in Cylinder Conditions Affecting the Performance of An Oil Engine —New Method of Examining Indicator Diagrams for Cause of Low Efficiency— Typical Diagrams Showing Defects of Actual Engines

By P. H. SCHWEITZER

MANY engines, both steam and internal-combustion, fail to prove as efficient in operation as when first tested. The trouble is largely traceable to misadjustment or mishandling of the engine. The mechanical losses are fairly constant and it is a change in cylinder conditions which causes the drop in the engine's performance. Knowing this, the intelligent engineer makes use of the indicator as a means of discovering valve misadjustment, improper distribution of the work, radiation losses, etc.

An indicator diagram shows the pressure changes in an engine with considerable accuracy, but fails to show where heat is absorbed and where heat is given up by the cylinder contents. This is a very important point in an internal-combustion engine, where both the production of heat and its conversion into mechanical work are performed within the cylinder. In studying the performance of the engine, knowledge of the heat movement is essential. To overcome this difficulty the author has developed a method of analyzing the indicator diagram which has been of great assistance in oil-engine testing.

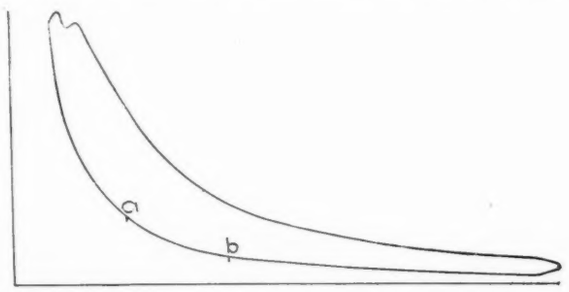


FIG. 1—DIAGRAM FROM ENGINE SHOWING HEAT ABSORPTION

In theory it is usually assumed that the compression and expansion lines of an internal-combustion-engine cycle, are adiabatics, that is, processes where heat is neither absorbed nor given up by the gases save the heat equivalent of the work of compression or of expansion. In fact, this is never the case, for a continuous interchange of heat takes place between walls and cylinder contents. During the early part of the compression stroke heat is taken up from the cylinder wall, which is still hot from the preceding explosion, by the fresh air or air-gas mixture. During the latter part of the compression the compressed air reaches a temperature much above that of the cylinder wall and gives up its heat to the water-jacketed wall. If the cooling-water flow is heavy, the heat loss may be considerable.

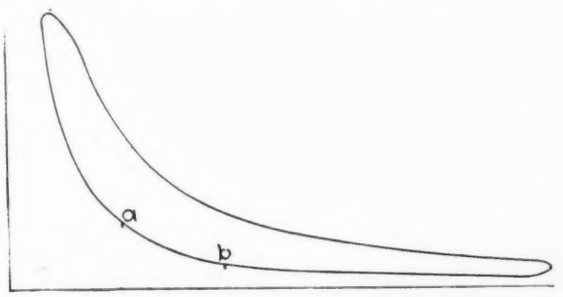


FIG. 3—DIAGRAM SHOWING HEAT LOSS DURING COMPRESSION

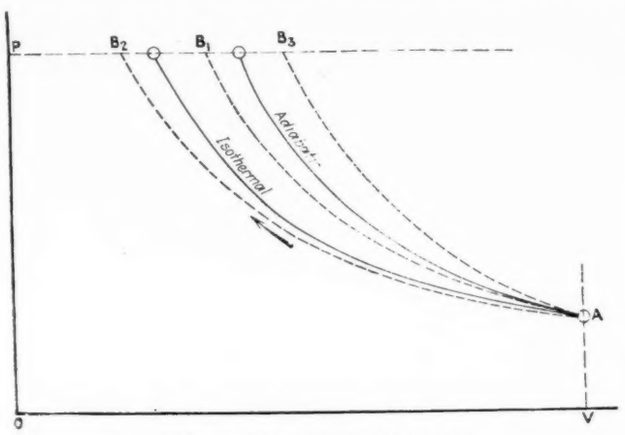


FIG. 2—COMPRESSION LINES

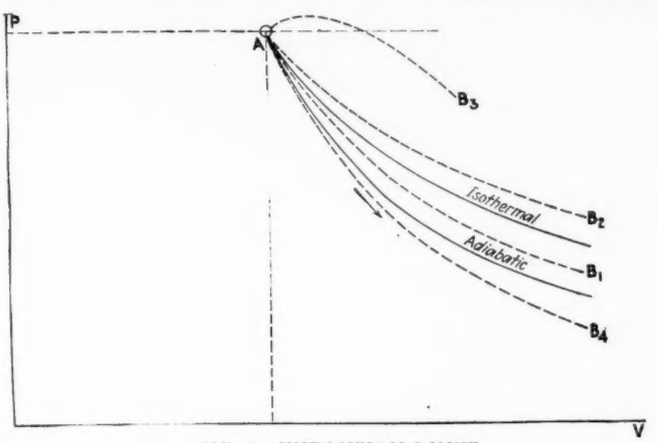


FIG. 4—EXPANSION LINES

The heat developed by the combustion of the mixture makes the conditions during the expansion stroke even more complex. But for the sake of simplicity in calculations, the expansion line is usually considered to be adiabatic, ignoring the wall effect and assuming that the combustion is carried out instantaneously, or at con-

stant volume, in the Otto cycle or limited to the injection period in the Diesel cycle.

Examination of the actual process reveals the fact that the combustion is not limited to such short periods, but is spread over a considerable portion of the expansion stroke. Small burning particles remain in the gas long after the ignition and fuel injection is over, and in many engines the combustion is not finished when the exhaust valve opens. Sometimes flames or smoke appear in the exhaust, and at times unburned gases leave the cylinder, taking along their latent power into the atmosphere. All these conditions are indications of afterburning. On the other hand, their absence is no proof of perfect combustion.

Expansion Not Adiabatically

Bearing in mind the influence of the extended burning and the cooling loss, we cannot expect the gases to expand adiabatically. Indeed, in the beginning of the stroke where most of the fuel is burned, the introduced heat will prevent the line from falling as fast as the adiabatic. At the end of the expansion the line on the indicator diagram might be steeper than the adiabatic by reason of the effect of the cooling.

According to the variable influences of the ignition, burning, cooling, etc., the compression and expansion lines of different engines will be different and will have characteristics peculiar to the engine.

The indicator diagram gives a true picture of the pressure-volume changes taking place in the cylinder; hence all the differences in the expansion and in the compression lines should manifest themselves on the diagram. They really do, but are hardly noticeable by a simple inspection of the curves, the difference in

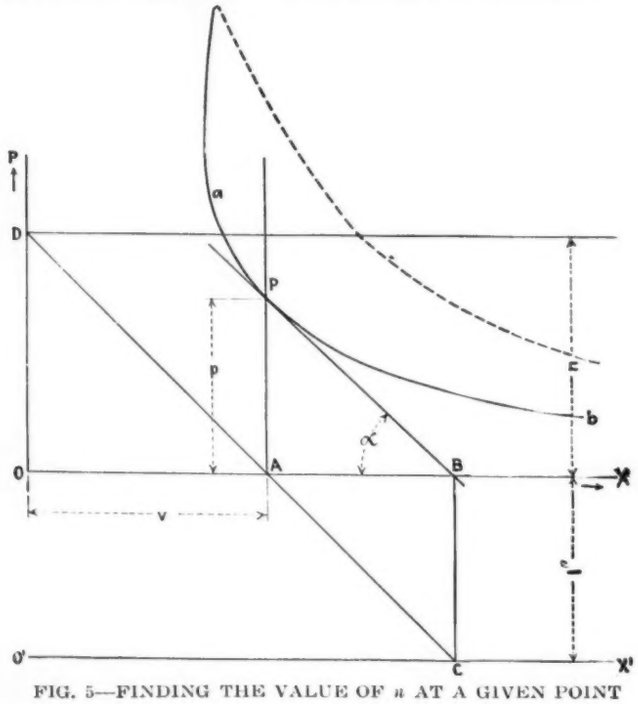


FIG. 5—FINDING THE VALUE OF n AT A GIVEN POINT

shape being too slight to detect. As example the compression lines of the diagrams Figs. 1 and 3 look similar. Nobody could tell by a glance that in Fig. 3 heat is absorbed by the cylinder contents, while in Fig. 1 heat is lost to the walls in the *a-b* portion of the compression stroke.

By comparing the actual compression line with an adiabatic, one can tell immediately, whether the gas is heated or cooled from outside. When cooling exists during compression, the curve will fall under the adiabatic as does AB_1 in Fig. 2. It can even lie below the isothermal as does AB_2 if the cooling is sufficiently strong. If, instead of cooling, there is heating during the compression, we may get AB_3, a line above the adiabatic.

During expansion heat introduction causes the pressure line to rise above the adiabatic. If the introduced

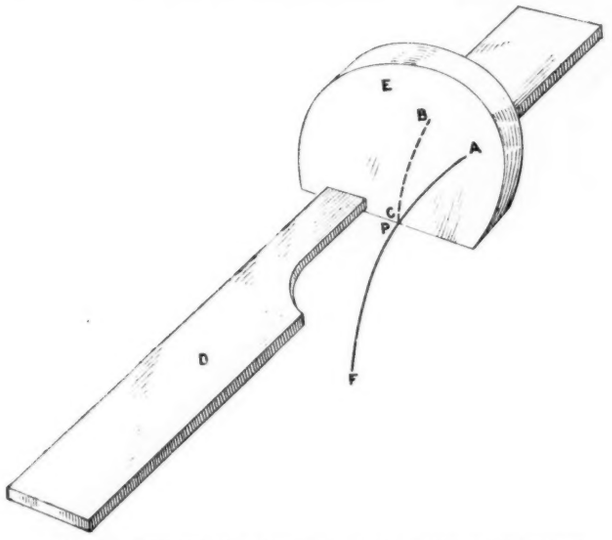


FIG. 6—MIRROR DEVICE FOR DRAWING TANGENTS

heat is not equal to the heat equivalent of the work of expansion, the line will lie above the adiabatic but below the isothermal, like AB_1 in Fig. 4, consequently the temperature will steadily fall. If the amount of the introduced heat is so much that the temperature rises in spite of the expansion, as for example, during the fuel injection periods of a Diesel engine, the pressure curve will run above the isothermal as do AB_2 or AB_3 in Fig. 4.

If heat is lost to the cylinder walls during expansion, the curve AB_4 will drop below the adiabatic. In other words, during compression added heat makes the pressure line steeper; during expansion it makes it flatter. Cooling has the opposite effect.

Comparing the Actual and Theoretical Curves

To find out what is actually happening at a certain point of an indicator diagram, all we have to do is to draw an adiabatic through the point. Then the foregoing rules will tell us whether heat introduction or heat deduction is taking place. To draw adiabatics at several points on the diagram is tiresome and the comparison made inaccurate, as these curves are close together. Even the most careful construction to an enlarged scale would not make the study of heat changes feasible.

If the cylinder contents do not receive heat from a continuation of the combustion or do not lose heat to the walls—that is, if the process is adiabatic—the relation of the pressures and volumes is expressed by the equation PV^k constant. The exponent k, which is the ratio of the specific heats of the mixture, varies with different mixtures; it is 1.41 for air at ordinary temperatures. If the cylinder mixture is changing its heat content, the exponent in the pressure-volume equation will be n, different from k. It can be readily understood

that when the pressure line is steeper than the adiabatic as AB_2 in Fig. 2, or AB_4 in Fig. 4, the exponent n is greater than the adiabatic exponent k. If the pressure line is flatter than the adiabatic, as AB_1 and AB_3 in Fig. 2 or AB_1, AB_2 and AB_3 in Fig. 4, n will be smaller than k.

Comparing this with the preceding, the rule can be translated as follows: On the compression line there is gain of heat if n is greater than k and a loss if n is less than k. On the expansion line there is a gain of heat if n is less than k and a loss of heat if n is greater than k.

A simple graphical method of determining the value of n at any or all points along the expansion and compression lines has been developed. In Fig. 5 the line ab represents the compression curve, OX is the zero absolute pressure line and OP the zero clearance line of an indicator diagram. Below and parallel to OX at any convenient distance, say one inch, construct the line $O'X'$. Assume that the value of n of the compression line at the point P is desired. Draw the line BP tangent to the curve ab at P, and erect the perpendiculars BC and PA. Through A and C draw CA extended to D on the zero clearance line. Now the ratio $\frac{OD}{BC}$ is equal to the value of n at the point P. If BC be made equal to one inch, the value of n or OD is measured directly by a scale. The mathematical proof of the construction is given at the end of this discussion.

What the Constrcution Reveals

By determining the value of n at several points on a curve and combining them into an "n" curve, a true picture is had of the heat movement during the entire cycle.

The n curves of an indicator diagram will reveal the following facts:

1. When the temperature increases.
2. When the temperature decreases.
3. Where the peak of the temperature ($n = 1$) occurs.
4. When heat is introduced to the gas.
5. When the gas loses heat.
6. Whether the ignition is early or late.
7. Whether the combustion is fast or slow.
8. The amount and duration of the after-burning of the mixture.
9. Whether the cooling is efficient.

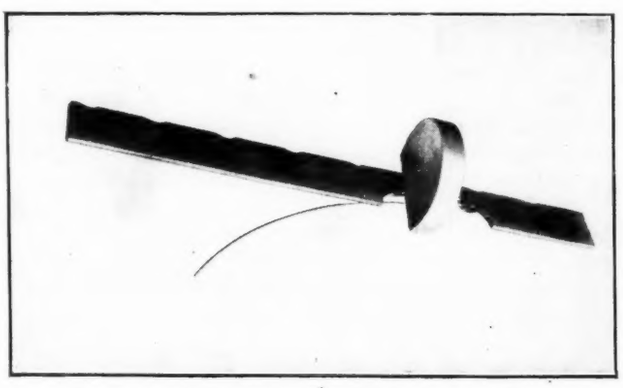


FIG. 7—PHOTOGRAPH OF MIRROR AND SCALE

10. On which part of the cylinder the cooling is strong.
11. On which part of the cylinder the cooling is weak.
12. Whether friction is excessive.

Thus the n curve shows the defects of the design and adjustment of a constructed machine and gives the test engineer a chance to correct any error. It enables the designer to locate the weak points of the engine and gives the operator indications, acting upon which he may make changes conducive to increased economy and efficiency.

To draw tangents to a curve accurately and quickly, the mirror method may be used. The device is shown in Fig. 6, and consists of a rule D to which is attached at right angles a mirror-like polished metal block E. The point C which is in alignment with the edge of the scale is marked on the edge of the block. The device is placed on the indicator diagram with the point C in contact with the point P on the curve to which it is desired to draw a tangent. When the image AC appears as a continuation of the original curve PF, the edge of the rule is tangent to the curve at P and the tangent line is drawn. If the scale is not tangent, the reflection of the curve will be somewhat as shown by the broken line BC. In Fig. 7 is shown a reproduction of the mirror in use.

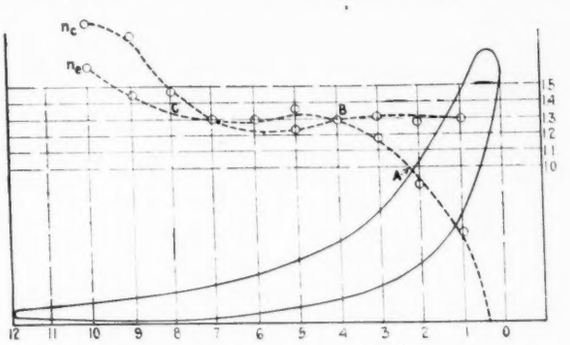


FIG. 8—INVESTIGATION OF INDICATOR DIAGRAM

Study of an Actual Diagram

This has been done for the diagram in Fig. 8. The line marked n_c is the n curve of the compression line, while n_e is that of the expansion line. The diagram was taken from a 21x34-in. single-cylinder horizontal four-stroke-cycle Diesel rated at 180 hp. The compression ratio was 19.5 to 1. An examination of the n line for the compression stroke shows that it starts much above 1.41, this being the value of the exponent k for adiabatic compression of air. The high value (close to 1.7) indicates that heat was introduced at the very beginning of the compression. This heat evidently came from the hot cylinder walls, and the process of heat introduction continued at a falling rate until the piston passed the point 8. From this point until the end of compression n has a fairly uniform value, indicating that the jacket cooling-effect is good.

The expansion n line starts below zero, which means that the combustion at the beginning of the fuel injection is so rapid that the pressure rises in spite of the increase in volume. The n curve rises sharply until it has a value of $n = 1$ at A. Since in the equation $P_1 P_1^n = P_2 V_2^n$, the temperature is increasing as long as n is less than unity and when n becomes unity isothermal expansion exists. A indicates the point at which the temperature in the cylinder reaches a maximum. The combustion evidently proceeded up to the point B.

From B to C the n curve is almost horizontal. Since there is a heat loss to the cooling jacket, it is evident that to compensate for this loss and keep n constant there must have been some combustion all along the

stroke to C. Shortly after C the line cuts the 1.41 value, hence heat introduction ceases, and the increased slope to the end of the stroke reveals that the jacket cooling effect is quite pronounced.

This study of the diagram shows that the engine is a good average machine with good cooling and fair combustion; in fact, the engine has no particular deficiency although there is moderate afterburning and too much heating during the compression stroke.

Proof of the construction in Fig. 5 is as follows: From the similar triangles

$$OD : OA :: BC : AB$$

$$OD = \frac{OA \times BC}{AB}$$

Since $OA = v$, $BC = 1$ and $AB = \frac{p}{\text{tangent } \alpha}$, we may set

$$OD = -\frac{v}{p} \tan. \alpha$$

But

$$\tan. \alpha = \frac{dp}{dv} \text{ and } pv^n = C$$

$$\frac{dv}{dp} = (-n)v^{-n-1} = -n\frac{p}{v}$$

$$n = -\frac{v}{p}\frac{dp}{dv} \text{ or since } OD = -\frac{v}{p}\frac{dp}{dv}$$

$$OD = n$$

Phillips Rubber-Tube Turbine Expansion Joint

A rubber tube as the expansive medium between a steam turbine and its condenser has been devised by W. H. Phillips, of Chicago, into a simple expansion joint which has been tried out in service with success.

The construction and details of this joint are brought

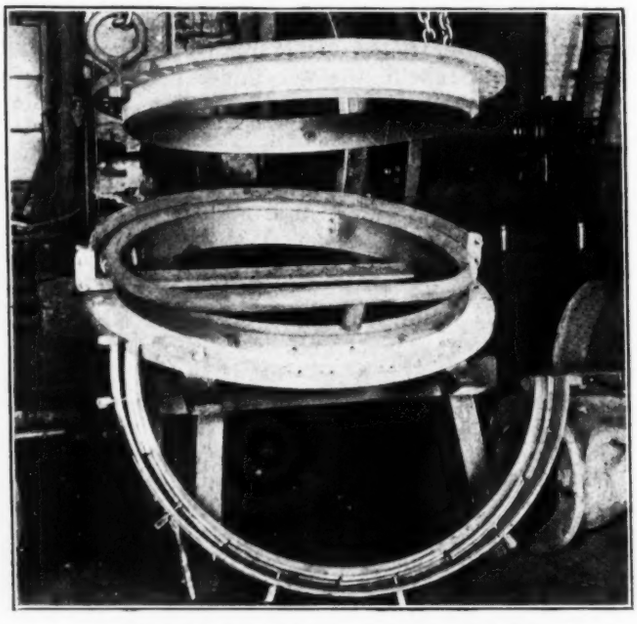


FIG. 1—PHILLIPS EXPANSION JOINTS DISASSEMBLED TO SHOW CONSTRUCTION

out in the accompanying illustrations, Figs. 1 and 2 being from photographs taken of a 48-in. joint which was installed between a turbine and a condenser unit that had been in operation for three years. The condenser had been mounted on springs and considerable trouble had been experienced from vibration. It was lowered 13 in., the length of the vertical expansion joints in the circulating water piping, grouted to its foundation and a rubber expansion joint installed. This unit is now operating satisfactorily.

Referring to Fig. 3, particularly the vertical section, it will be seen that the joint consists of two cast-iron

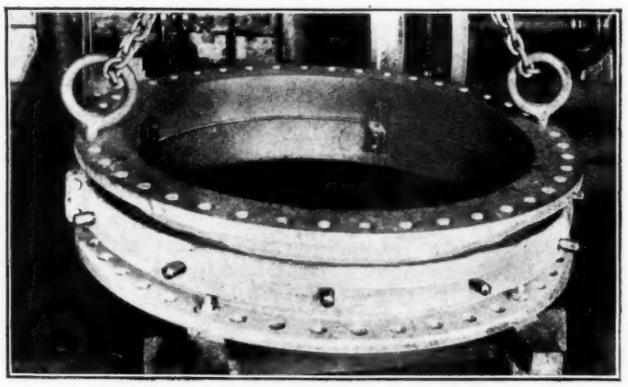


FIG. 2—ASSEMBLED VIEW OF JOINT

flanged rings, the upper one being bolted to the turbine exhaust flange and the lower ring to the condenser. The two flanged rings are spaced $\frac{5}{8}$ in. apart, and a radial groove is turned in the adjoining edges of the rings of proper radius and depth to receive the rubber tubing which makes the flexible joint. The maximum movement between the average condenser and turbine setting does not exceed $\frac{3}{16}$ in. for the greatest ranges of temperature encountered.

To prevent oil dropping from the turbine onto this rubber tubing, a cast-iron water seal casing, bolted to the lower flanged ring, has been provided. This casing also carries the adjusting screws by means of which pressure plates may be forced against the tubing to hold it in place.

Depending upon the size of the joint, four or more connecting plates are provided to hold the two rings in alignment during installation. These connecting plates are bolted to both rings inside of the joint, as indicated at C in the sectional elevation and the plan view of Fig. 3. They are removed after the flanges have been bolted into place.

After the metal parts of the joint have been installed, the final operation is the introduction of the rubber tubing. It is an all-rubber tube with no fabric and is sufficiently pliable to be used on joints of 24-in. diameter without special molding, so that all joints inside or outside, flanged, round, oval or rectangular, of any size where the radius is not less than 12 in., employ the same standard size of tubing.

Before installation, this flexible tubing is cut to the proper length and the ends are painted with two applications of rubber cement which is allowed to dry. The handhole plate A is removed and all the pressure-plate adjusting screws are backed out, so that the tubing may be threaded through between the pressure plates and its radial seat until both ends are opposite the handhole and the tubing is in its seat all the way around. Then both ends of the tubing are brought to the center of the handhole and pulled tightly into place, and the pressure-plate screws are tightened to hold it. The rubber joint plug B is then inserted in each end of the tubing for one-half of its length and the ends of the tubing

are pressed together. The handhole plate then may be fastened into position and its pressure plate tightened. The rubber cement sets almost instantly, so that all the pressure plates except the one at the handhhole may be loosened and reset in light contact with the tubing, just sufficient to hold it against its seat. During the periods when the unit is in operation, with a vacuum inside the joint, atmospheric pressure will of course perform this function. The water-seal

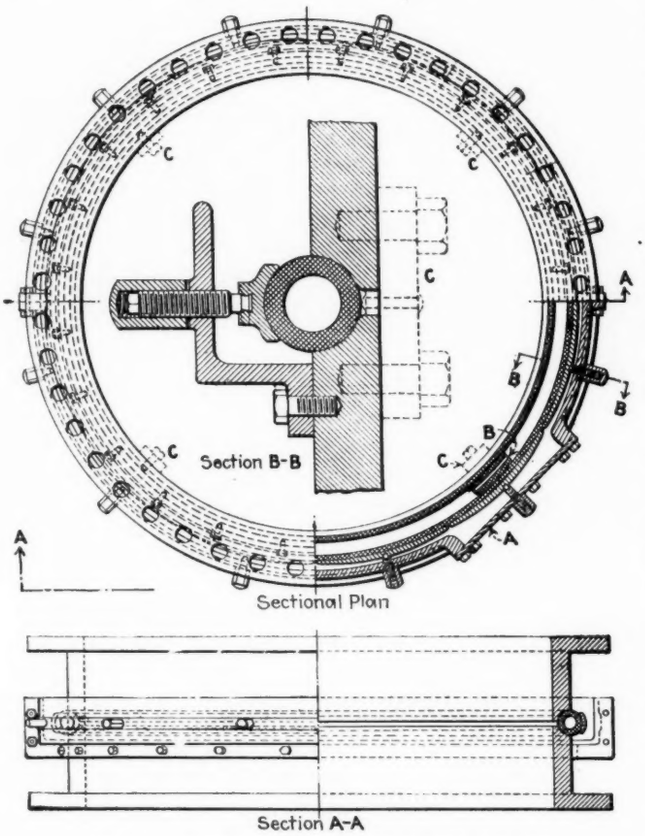


FIG. 3—EXPANSION JOINT IN PLAN AND SECTIONAL ELEVATIONS

ring, which is included more as a protection against oil than as a seal, should be provided with supply and overflow pipes, and when it is filled with water, the joint is ready for service.

Patents have been applied for, and the joint is now being made by the Henry Pratt Co., Chicago.

M. Farrer, manager of the Twickenham & Teddington Electric Supply Co. (England), writing in the *Fuel Economy Review*, stated that in his own station the records of the coal meter are logged at the end of each shift and a chart is prepared showing the record of each stoker on each shift. Very interesting and valuable results have been obtained from these records. It was found, for instance, that a certain stoker produced far better results on the night shift than any other of his mates. Another stoker obtained poor results on the night shift, but did very well on the heavy evening shift. On the other hand, certain men who had for years been considered good firemen were found to be consistently behind the other men on either light or heavy shifts. From a test of his Lea coal meters using small coals from seven separate collieries, the results varied from —2.4 to +6.9.

Abrogation of Contract Power Rates

BY A. L. H. STREET

The validity of a special long-time contract to supply power for industrial use, as against attempt to increase the agreed rate within the life of the contract, under statutory authority subsequently vested in a public-utility commission, was the subject of the interesting and important opinion handed down by the Virginia Supreme Court of Appeals in the recent case of Commonwealth vs. Shenandoah River Light & Power Corporation, 115 Southeastern Reporter, 695.

A milling company and an electric company were controlled by the same stockholders, the mill supplying the electric company with energy. The assets of the electric company were sold to a power company under a contract obligating the latter to furnish the milling company with power for twenty years at a fixed rate. Later authority was vested in the Virginia Corporation Commission, by statute, to regulate the charges of public-service companies. Under this authority the Commission fixed a schedule of rates to be charged by the power company to its customers, rates in excess of those fixed in the contract referred to.

The suit mentioned involved an attack upon the right of the Commission to abrogate the rate that it was enjoying under the unexpired contract. The court decided that the milling company did not have such vested rights under the agreement as precluded abrogation of the agreement, especially because when the contract was made the commonwealth's Constitution reserved power to control the charges of public-service corporations. But it was ruled that on a showing that the power company received valuable property or rights on the faith of the contract to furnish power to the mill at the agreed rates, it would be proper for the Commission to give the milling company an appropriate classification and special rates under that classification.

It was further decided that, under the Virginia law, the contract rate, although subject to abrogation under the sovereign power of the commonwealth, must be respected until the Commission should abrogate it on a finding of public interest. The court said:

> There is a presumption that such contracts will be performed, and they are obligatory upon the parties thereto until and except the state shall exercise its sovereign power to modify, suspend, or abrogate them in the public interest. Until this power is exercised, for the reasons and in the method prescribed, such contracts remain effective. In cases like this, when it is shown that there is an outstanding contract by which the rate involved was established, then the Commission should suspend the proposed rate, which contravenes such a contract, for such reasonable time as is requisite for the submission of the evidence and the completion of the necessary investigations and hearings. . . . To hold otherwise would be to enable one of the parties bound by a contract to evade its obligations without cause assigned or shown, and thus accord to such action the sanction which can only be accorded to action by the state after cause has been shown. A fair construction of the statutes referred to indicates that contract rates may not be changed by the state until and except there first be an investigation and a finding of facts from which it can be adjudged that such rates must and should be modified, suspended, or abrogated for the reasons stated in the statute, and in the public interest.

Bearing pressures of 5,000 lb. per sq.in. can be used if some means is provided for lifting the shaft off the liner when starting.

Operating Alternating-Current Systems in Parallel

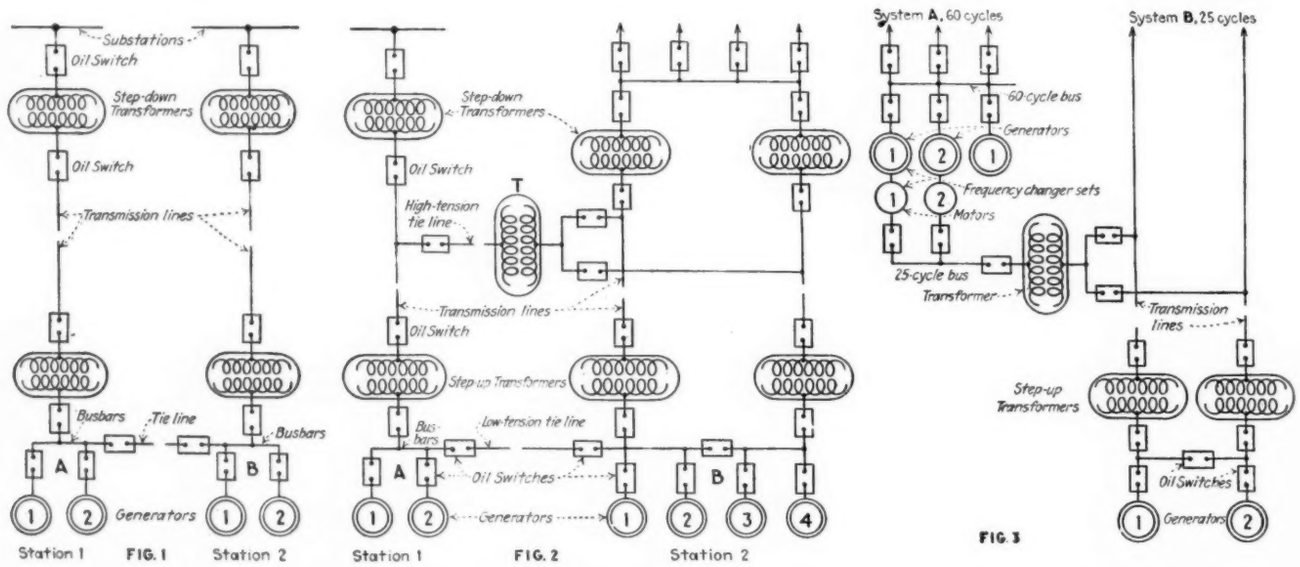
Conditions To Be Complied with When Operating Two Power Plants in Parallel With and Without Transformers—Parallel Operation Through Frequency-Changer Sets

BY RALPH BROWN*

IT IS often desirable to transfer power between two alternating-current systems operating at the same frequency and voltage, and Fig. 1 shows the simplest arrangement that will permit of such an interchange of power. The systems may be synchronized at either generating station through the tie between the buses, and for all practical purposes each system may be considered as one generator. The same considerations that apply to synchronizing generators, as outlined in the article "Operating Alternating-Current Generators in Parallel," (March 20 issue) must be kept in mind, also the limitation that the amount of power that can be transferred depends on the current-carrying capacity of the tie line. Assuming that the systems have been synchronized, power will flow from the system with the highest speed setting on the prime movers, and the wattless current that will flow will depend on the voltage at *A* and *B*, the station operating at the highest voltage supplying the greater amount of lagging current. If the tie line indicated in Fig. 1 is of sufficient capacity to carry the entire output of station *A*, the stations can be operated in parallel under practically all conditions.

Consider a case where two large transmission systems are connected together through a tie line or through transformers having a capacity but a small percentage of that of either system. Under this condition it will be necessary, in order to avoid damage to the tie line or transformers, to separate the stations on the occurrence of severe overloads on the system to which power is being transmitted. For this reason, if an overload indicated by low frequency should occur on two interconnected systems, the loading of only those generators connected to the system at fault should be increased, or the transformers or tie line might be dangerously overloaded.

Fig. 2 is similar to Fig. 1, except that the systems may be paralleled on the line side of the transformers or through the low-tension tie line. This form of connection is frequently met with, but in some cases the transformer connections are such that one tie line must be kept open while the other is closed. For example, if the transformers at *T* were connected delta-star, instead of delta-delta, assuming that the step-up transformers are connected delta-delta, a permanent phase displacement of 30 deg. would exist between the voltages of the generator buses when the systems were in parallel through transformer *T*.



FIGS. 1 TO 3—ONE-LINE DIAGRAMS OF DIFFERENT METHODS OF CONNECTING TWO ALTERNATING-CURRENT POWER PLANTS IN PARALLEL

Sixty-cycle and 25-cycle systems are commonly operated in parallel and owing to the difference in frequencies, frequency changers must be employed to permit of parallel operation. As commonly constructed, a frequency changer consists of a synchronous motor directly coupled to a synchronous generator, and for 25- to 60-cycle conversion the 25-cycle end usually has 10 poles, with 24 poles on the 60-cycle end, corresponding to the highest common synchronous speed of 300 r.p.m.

In Fig. 3 the frequency of system *A* is assumed to be 60 cycles, while that of system *B* is 25 cycles, and the two systems are to be synchronized. Since conditions

*The Great Western Power Company.

are better for synchronizing if a frequency changer is started on the low-frequency side, the 25-cycle element would be started by the application of low voltage usually obtained from an auto-transformer and would be transferred to the full voltage, or running position, with the field over-excited, in order to prevent an

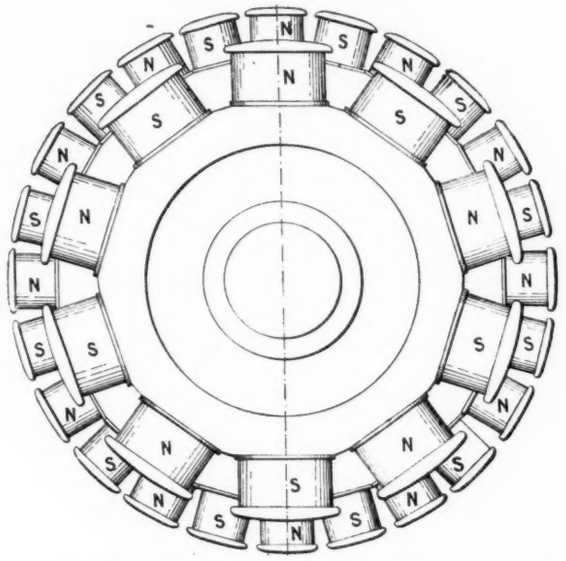


FIG. 4—SHOWS RELATION BETWEEN THE POLES OF A 10-POLE AND 24-POLE MACHINE

excessive armature current, when synchronous speed was attained. When transferred to the running position, the 25-cycle element would be operating as a synchronous motor, and the frequency of its generator would be 2.4 times that of system *B*. After exciting the field of the generator it could be synchronized in exactly the same manner as any generator, any necessary change in frequency being effected by changing the frequency of either or both systems by adjusting the speed of the prime movers driving the generators. After the systems are paralleled, power can be transferred only by adjusting the governors on either system, and would flow to the system having the lowest speed setting. Since the systems are mechanically connected through the shaft connecting the motor and generator of the frequency set, each element is subject to independent voltage and power-factor control. If the capacity of such a frequency changer is small as compared with that of either system, it will be subjected to severe shocks on the occurrence of even minor system disturbances, and may drop out of synchronism.

Connecting Frequency Changers in Parallel

Assuming that No. 1 frequency changer in Fig. 3 is connected to both buses, is operating at zero load, and that No. 2 is to be synchronized, a number of complications arise, and these will be considered. Owing to the ratio of the number of poles of the generator to those of the motor being 2.4 to 1, the phase relations of the generator voltages may not be correct for synchronizing when both motors are operating at synchronous speed from the 25-cycle bus. Examination of the two rotors of a 10- and 24-pole frequency changer will disclose the fact that only two poles having like polarity are exactly in line in a direction parallel with the shaft, as indicated in Fig. 4 where the two sets of poles are shown projected on each other, and the generator ends of such sets cannot be paralleled unless these corresponding poles are exactly in line at no load.

The reason for the possible phase difference on the generator end at no load can be understood if the elementary theory of operation of a synchronous motor is considered. In a 25-cycle motor the current flowing in the conductors in the armature slots establishes well-defined poles on the face of the armature, their polarity depending on the instantaneous direction of the current, and alternating 50 times per second. The effect of this constantly changing polarity is to establish a magnetic field which sweeps over the face of the armature in the direction of rotation of the rotor. The flux from the rotor poles, produced by direct current, reacts with the flux due to the armature current, the north poles on the rotor always being opposite the continually shifting south poles on the armature; and in order to fulfill this condition the rotor must revolve at the synchronous speed of 300 r.p.m. The north poles of the field are thus locked in synchronism with the south poles of the armature, and since there are five north poles, it is evident that the motor rotor will operate equally well in either of five different angular positions. If the frequency changer were started on the 60-cycle end, there would be but one position of the 12 possible ones satisfactory for motor operation which would permit of paralleling on the 60-cycle end.

Relation Between Motor and Generator Poles

Before the generator of frequency changer No. 2 can be synchronized, the angular position of its rotor must correspond with the rotor of No. 1 generator in order that the phase relations between the generator voltages shall be correct. But the relation of the rotor of the incoming generator will be correct for only one of the five possible positions of the motor rotor, hence there can

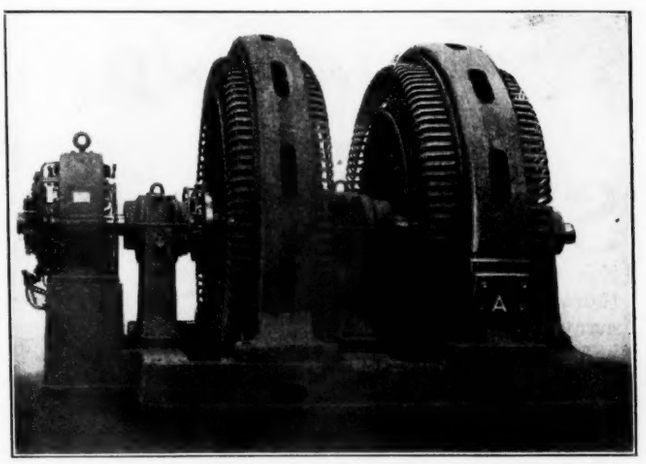


FIG. 5—FREQUENCY-CHANGER SET. CRADLE TO PERMIT SHIFTING THE STATOR IS SHOWN AT *A*

be but one chance in five of the generator's being in phase with the 60-cycle bus.

If a field reversing switch is not used, two ordinary synchroscopes will be required to make parallel operation of frequency changers possible. Assuming that the synchroscope on the 60-cycle side indicates that the generator is out of phase the field current of the motor should be adjusted for unity power factor, the generator field switch opened, and the motor running switch opened. The speed of the motor will slowly decrease, and the motor's running switch should be closed to the

25-cycle bus the first time that synchronism is indicated, which will be when the rotor has slipped back one pair of poles. Each revolution of the motor's synchroscope pointer corresponds to one cycle, or 360 electrical degrees, and to 2.4×360=864 degrees on the generator. This procedure of slipping poles is continued until synchronism is indicated on the 60-cycle end, and under the worst possible conditions the motor would require synchronizing four times.

If the 60-cycle synchroscope is provided with a special dial, the position which it assumes directly indicates the number of pairs of poles to be slipped, and the 25-cycle motor is separated and resynchronized according to this indication. Where field-reversing switches are used, a synchroscope is not required for the motor, provided that it is started as an induction motor, the 60-cycle synchroscope indicating the number of pairs of poles to be slipped after the motor is running. Each reversal of the motor field switch causes the 25-cycle rotor to fall back 180 electrical degrees, or one-half cycle, and the motor field is repeatedly reversed until the 60-cycle synchroscope indicates that the phase relations of the generator and line are correct. If a special synchroscope provided with 25- and 60-cycle elements is used, the 25-cycle pointer will always indicate synchronism when the motor is connected to the bus, and if the 60-cycle pointer is not in line with it, the motor running switch is opened, and the motor synchronized when both pointers are in the vertical position. Closing the generator switch at normal voltage then parallels the frequency changer on the 60-cycle bus. Or the set may be synchronized on the generator end and the motor switch then closed.

It has been assumed in the foregoing that the frequency changers were being synchronized under no-load conditions. If one generator is loaded, its voltage cannot be in phase with that of a generator operating without load, because of the impedance of the armature and the angular displacement existing between the rotating parts of the two generators. The phase difference between the voltages of the bus and the incoming generator may be 60 deg. or more, but this difference will only cause a momentary rush of current, the unloaded generator immediately assuming load.

The load on the generators of frequency changers operating in parallel cannot be appreciably altered by changes made in the field currents of either the motors or generators, division of load being accomplished by interchanging the armature leads, termed "spiraling," and slipping poles, or by shifting the armature of either the motor or generator of those units on which the load is to be changed. The most satisfactory method is to shift the armature, but as there are objections to installing the necessary mechanism to permit of quickly rotating the stator frames, through a small arc, provision is seldom made for changing the loading of individual units. Since frequency changers of identical design and construction may not properly share the load when first paralleled, the motor or generator of such a unit is generally provided with an adjustable cradle as indicated at *A*, Fig. 4, to facilitate shifting the armature so that proper division of the load will be obtained. Assuming that adjustments have been made to insure correct division of load when power is flowing in one direction, say from the 25-cycle system, the division of load may not be correct when power flows in the reverse direction and adjustments would have to be made again.

The voltage of a generator forming part of a frequency changer is controlled in the same manner as that of any alternating-current generator, generator voltage regulators being widely used. Field current is generally supplied by direct-connected exciters, and, as with any synchronous generator, voltage regulators may be used with frequency changers.

Why the Ice Plant Bought Ice

By ROLAND L. TULLIS

SOME interesting difficulties in the overhauling and repair of a small refrigeration and ice-making plant were experienced some time ago. The condition of this plant certainly pointed out the need of a more thorough knowledge on the subject of refrigeration by many engineers.

Although the institution was a large hospital, the ice plant was only a small one of eight-ton capacity, but for obsolete equipment and difficult operating conditions it would be hard to beat. The ammonia compressor was an old design, vertical single-cylinder unit, single-acting, 6-in. bore by 8-in. stroke, and was driven from a lineshaft the bearing of which was bolted to the wooden beams of the engine-room ceiling. Above this ceiling was the kitchen of the institution.

When I first talked with the manager, he explained some of the shortcomings and undesirable features of the plant. He said that it was impossible to run the compressor later than eight o'clock at night as its pounding would keep the patients awake; starting it up at six o'clock in the morning was an unfailing alarm clock. The lineshaft attached to the kitchen floor caused it to vibrate until the dishes all landed on the floor

There was a congealing or brine tank with a capacity of twenty 100-lb. cans, still they were buying ice at the rate of five to seven hundred pounds a day. The manager wanted to know what was wrong. I told him that it would probably prove to be a long story, but that I would try to find out.

The outboard bearing on the crank shaft of the compressor had worn down to about one-eighth of an inch. This threw the whole machine, including the piston rod and crosshead guides, out of line and caused the piston-rod packing to wear out in an unreasonably short time A leaky piston rod on a compressor is one of the quickest and surest means of losing an ammonia charge, and since this plant was equipped with a small ammonia receiver, unless the engineer was watchful his ammonia charge would become low and dry gas would go over to the coils.

The next move was to examine the valves in the compressor, which were found to be in bad order. The suction-valve spring was about twice as heavy as the discharge spring. I questioned the so-called engineer, or handy man, about his reason for putting such a heavy spring on the suction valve. He explained that some fireman or helper about the engine room had removed the valve caps on the compressor. Finding one of the springs broken, and there being no spare ones, he had picked up a spring that would fit and used it on the

valve. He could not see what difference it would make if the spring was a little stronger, as it would last that much longer. This spring was so strong that part of the time it would refuse to open. One can imagine what the volumetric efficiency of this compressor was. Volumetric efficiency meant nothing in this engineer's young life.

We were compelled to overhaul the compressor thoroughly, rebabbitt and adjust the bearings, fit and grind

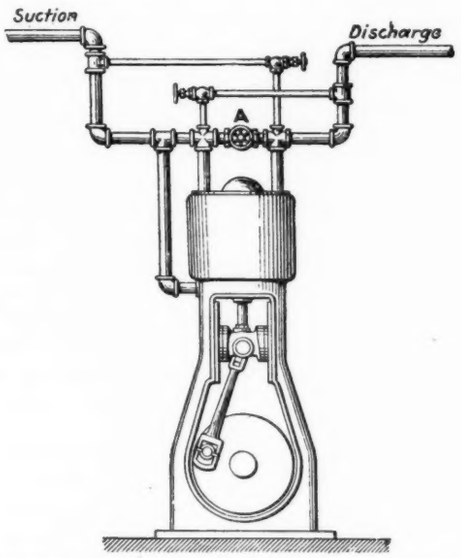


FIG. 1—ARRANGEMENT OF BYPASS LINES

the valves and adjust the spring tensions. After it had been overhauled, it was given a simple test to ascertain whether it was working properly. There was no feasible way of applying an indicator; probably the machine was designed before the day of indicators. We simply closed the valve on the suction side and ran the compressor at full speed to see how much vacuum it would pump. Since the vacuum could not be lowered below 10 inches, evidently there was still something wrong. Next it was discovered that the compressor was connected up in a peculiar manner. As will be noticed in Fig. 1, there was a bypass connection *A* with a globe valve between the suction and discharge pipes of the compressor, also the usual cross-connections used for pumping from the high side to the low or vice versa. Upon examination it was found that the large bypass valve *A* was leaking badly, allowing the high-pressure gas to leak back into the suction, thereby decreasing the efficiency of the machine. We repaired the seat of this valve with a reaming tool and supplied it with a new disk, but it still continued to give us trouble. There was no strainer on the suction line of the compressor, and it seemed that the system was foul with dirt, rust and small particles of burnt-out packing that had evidently worked up through the gland of the compressor and circulated through the system . Every time the globe valve was opened, some of the foreign matter would lodge under the seat. To eliminate further trouble from this source, the large bypass line and valve were removed, and one of the small cross bypasses used for starting.

After getting the compressor as nearly as possible into first-class shape, attention was turned to the brine tank and circulating system. Here another curious situation was found. The brine tank was about 10 ft. by 14 ft. by 5 ft. in dimensions and contained spaces for twenty 100-lb. standard cans, but only sixteen cans were in use at the time. There were four banks of cooling coils of the usual type with the cans resting between.

The refrigerator rooms were located in the kitchen above the engine room and the brine-circulation system was used for cooling, the brine being circulated by a small centrifugal pump. There was no provision for agitating the brine in the tank except the circulation caused by the suction and discharge of the pump. The return brine emptied into one corner of the tank, while the suction of the pump received its supply from the opposite corner. In one corner of the tank top was a small hole to accommodate a thermometer submerged in the brine. This was the only means of ascertaining the brine temperature. The plant engineer complained that the temperature of the refrigerators was very high at times; lately he had been unable to get even frost on the coils despite the fact that the thermometer in the brine tank showed 17 deg. F. brine.

A thermometer was placed on the pump discharge line to ascertain the real temperature of the circulating brine, which was found to be 30 deg. It was evident that the pump was handling comparatively warm brine, although that in the tank was at 17 deg. The brine was next tested with a salinometer and found to be weak. The tank coils appeared to be almost a solid block of ice, that is, the coils were coated with about two inches of sludge-ice. In probing for the bottom of the tank with a stick, we discovered that there was about six inches of sediment or sludge on the bottom, evidently the accumulation of years. A wall of ice had formed in one end of the tank and over the banks of coils in such a manner as to provide a narrow channel

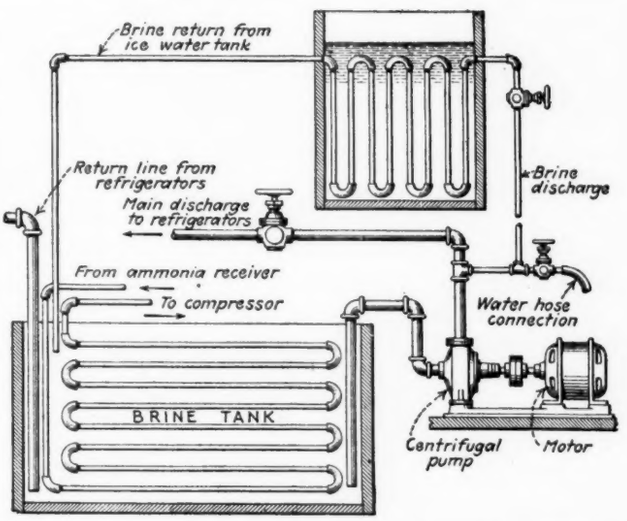


FIG. 2—HOW THE FIREMAN MADE THE BRINE CIRCULATE

around the edge of the tank through which the brine circulated, while the remainder of the tank remained practically isolated. The circulating brine had no opportunity to receive its cooling effect from the coils, which accounted for the high temperature, while in that portion of the tank where the thermometer was submerged, the brine did not circulate and remained at a much lower temperature.

There was so much sediment in the bottom of the tank that there was danger that it would clog up the pump or coils in case it was once stirred up properly. The tank had been in service about fourteen years, and

none of the old residents had ever known of its being cleaned. The clear brine was pumped into barrels and the sludge was washed down through a drain in the bottom of the tank.

When the tank and coils were thoroughly cleaned, we replaced the clear brine and made up the loss with water, but it required the addition of three drums of calcium chloride to bring the salinometer reading up to 70. This was sufficient as the brine temperature was never lower than 15 deg. F. After the brine tank was cleared of ice and sediment, no further trouble was experienced with the brine circulation, although the layout of the piping was the same.

A number of weeks later the temperature in the tank was tested in a number of different places, but no variation of more than two degrees was found. However, when we again tested the brine with a salinometer it was found to register only 53.

I questioned the engineer as to whether he had drained any brine out of the tank or added any water. Right there I stumbled onto another knotty problem. He explained that nearly every morning he was compelled to drain some brine out of the tank, for in some mysterious way the brine would gradually rise until it would reach the top of the cans.

The Mystery Is Solved by the Helper

Since there was no apparent way by which water could get into the brine tank, I questioned one of the helpers who worked the early morning shift, and always started the plant in the morning. At first he was not inclined to give out much information, but was finally impressed with the idea that there was something wrong and I intended to find out what it was. He finally loosened up and told all about it. It was a little pet trick of his own of which he was proud—not even the chief engineer knew about it. He could not explain how the thing had worked out; he had just stumbled on it by accident.

On the second floor of the building, 28 ft. above the level of the brine pump in the engine room, was a small water tank used to supply ice-water for drinking service. Brine was supposed to circulate through the coils in this tank to keep the water chilled, but a few months back they had begun to experience a great deal of trouble in getting the brine to circulate. Before the pump was shut down at night the brine would be circulating freely, but in the morning, when the pump was again started, the brine would refuse to move. The first supposition was that the coils were clogged or partly clogged with foreign matter. To test them out, both steam and air were blown through the lines and coils, but they appeared to be free and open. The chief engineer had given the problem up in disgust, but the fireman kept on experimenting. Finally, he discovered that by connecting a water hose, which was under pressure, to the brine line leading to the tank, and allowing the water to run for a few moments, when the water was shut-off the brine would continue to run as long as the pump ran.

It was a little secret all his own; he knew something that the chief did not. His little secret explained how the water was getting into the brine tank, why the solution was getting weaker every day, but he could not explain why this little stunt had to be performed every morning before the brine would start to circulate through the coils.

Fig. 2 outlines the piping layout. The ice-water tank was vertical and contained a great number of improvised vertical coils made of ¾-in. pipe. This great number of vertical coils with close return bends undoubtedly caused a great deal of friction and resistance to the flow of brine. The distance from the brine pump to the top of the coils was 28 ft., while the brine pressure at the pump was only 13 lb., when all the refrigerator valves were open. It will be seen that the brine pressure was insufficient to lift the 28 ft. and overcome the frictional resistance of the pipes, but when the additional pressure of water was turned on, the brine would be forced through the coils. Due to the drop of the return pipe, about 26 ft., there was added the vacuum or siphon effect of the brine in this return line, which was sufficient to cause the brine to circulate. Thus when the circulation was once started it would continue to run, but when once stopped it would not start without extra pressure. The trouble was cheaply cured by placing a valve in the main discharge line to the refrigerators. By closing this valve the centrifugal pump would increase its pressure sufficiently to start the circulation in the ice tank, whereupon the refrigerator valves could be opened. This was a rather makeshift arrangement, but worked very well and saved the expense of buying a new centrifugal pump of greater capacity and pressure.

After these few little improvements that I have described were completed and put into effect, the power consumption of the compressor was decreased over 30 per cent; 5 per cent was due to elimination of shafting, worn bearings, etc., while 25 per cent was traceable to the increased volumetric efficiency of the compressor, enabling four hours to be cut off the running time each day. We were also able to supply all the ice required. Perhaps this plant was exceptional, but there are many such plants in the country today needing the attention of an engineer.

In co-operation with the Fixed Nitrogen Research Laboratory the Bureau of Standards has made a microscopic examination of specimens representing a series of steels varying in carbon content from 0.02 to 0.98 per cent exposed to a current of ammonia at temperatures in the range of 100 to 700 deg. C. The purpose of this test was to determine the effect of change in carbon content upon the method of attack of heated ammonia. No change was observed on the specimens up to 400 deg.; at 500 deg. a film of white nitride was followed by the layer of nitride needles. At 600 deg. this effect increased, while at 700 deg. a new compound of nitrogen was formed following directly the film of white nitride layer. At 700 deg. with two low-carbon steels the nitride needles removed farther from the edge to the center. They are absent at that temperature in high-carbon steels of 0.49 to 0.98 per cent carbon. Twelve micrographs were taken and a detailed report submitted to the Fixed Nitrogen Laboratory.

De Laval and Rateau are generally given credit for being first in successfully commercializing the steam turbines. It is interesting to note that as early as 1836 steam turbines were built, sold and operated in the United States, some of which drove sawmills at Syracuse, N. Y. These were devised by William Avery, and were reaction wheels of the Hero type. The patent was issued in 1835 to Foster and Avery, being the first American turbine patent granted.

Boiler Inspection—VI

By James F. Hobart

THIS article deals especially with the internal inspection of the rear part of the boilers and points out where special attention should be given.

BEFORE going inside the boiler, have the inspection suit brushed free of loose dirt. Be sure you have plenty of matches in your pocket and place the candle beside the manhole where it can be reached easily after you are inside. If the boiler is one of a battery fasten the stop valve securely with a chain and padlock so that steam cannot be turned accidentally into the boiler while you are inside. When you first get inside, lie on your back or side under the manhole, and while holding the candle overhead and moving it all around, examine as much of the shell as possible. Look closely at the manhole plate or its reinforcing. Most modern manholes are made of pressed steel, and they do not require such rigid inspection as had to be given to the cast-iron plates once used.

If the boiler is hot, the fire having been out only a few hours, take a piece of board to place between your knees and the hot tubes. Also take along, in your pocket, a piece of picture wire four or five feet long, the use of which will be described later.

The writer usually inspects first the back end of the boiler. On the way, while crawling along, scrape and examine any rough spots on the shell. Investigate every lump on the tubes or plates and see if it is rust, dirt, scale or other deposit. Examine each joint carefully. Notice where the feed-water pipe discharges. One-half to two-thirds of the way back from the front head is the best place. The feed pipe should run in the steam space just above the tubes and should discharge between the tube and the shell, impinging against neither.

Examine the Rear Head

Examine closely every brace at the back end of the boiler. Strike each one with a hammer to see if it is loose or strained unduly tight. Look closely to the rivets fastening each brace to the shell or tube sheet. Note the length of the braces and see that none is less than thirty inches long, lest the angularity thereof be too great.

Count the braces so that the area stayed by each one may be calculated. Note the distance of the braces from the shell and the width of unsupported space between. The portion of the head two inches from the tubes and three inches from the shell will be sufficiently supported, but the remaining flat surface must be stayed. A stress of 7,000 lb. on each brace should not be exceeded. The rule of 5,000 lb. for each 1-in. round brace is a good one. The inspector should also look for welds in the braces. When rods are used, they should be forged, not welded.

If any incrustation or scale is found, cut it away and examine the surface underneath. Note if the deposit found is scale, or if soft, or of a greasy nature. Fig. 1 illustrates a horizontal cross-section through the rear head. It shows a thin place in the shell and a wasted spot in the tube sheet. Also shows deposits of dirt, mud and oil, and one of the tubes pitted badly. All such things the inspector must find and investigate, and incorporate them in his report after the inspection has been completed. A good deal of scraping is sometimes necessary to get below the soft deposits in a boiler. Some inspectors do not dig down through, to any great extent, they simply report "dangerous incrustation" and let it go at that. One usually finds little incrustation where the boiler is under the care of a competent engineer.

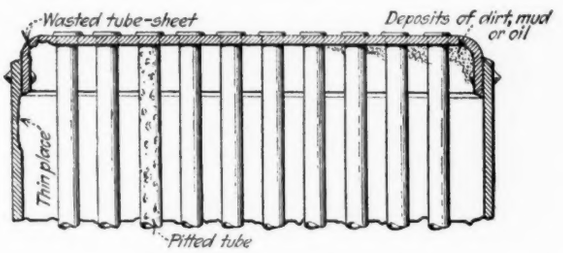
When there are no deposits, look carefully for corrosion or wasting of tubes. Find and report anything, including the pitting or wasting of tubes. It is seldom these things are present when the boiler is incrusted. Such deposits seem to protect the shell, therefore it is little use digging down into thick scale to find corrosion. It is when plates are free from scale that corrosion is most usually found, although it is often found under a heavy coating of rust or oxide.

Look closely to the conditions of the tube ends at the rear head. Dig into any mud that may cover them and watch for corrosion, or other thinness of metal; although wasting does not usually take place beneath scale, it does occur under a coating of mud.

Let the candle light shine down between the tubes as far as possible, and if you are not satisfied, take out the piece of picture wire and twist it around the candle, which may then be lowered between the tubes. In this way the inspector can see the condition of things for some distance down between them.

Watch for a Burned Plate

Examine closely the back head just above the top row of tubes for indications of overheating, which may be caused by the back arch being placed too high. Sometimes, when the arch is located too far from the tubes, fire plays directly against the head at a point where there is no water in contact with it. The result may be



HORIZONTAL CROSS-SECTION THROUGH REAR HEAD

cracking or burning of the tube sheet. The inspector should at all times be on the watch for such a condition.

If there is a fusible plug in the rear head at this point, cut into the soft metal slightly and note its condition. This should also be done while the inspector is in the rear combustion chamber. If the soft metal is found hardened to any extent or if the plug has been in use for more than a year it should be drilled or melted out and a new one put in its place.

If scale is found, cut down into it, determine its thickness and note it in your report. Also look for, examine and note the following: Sediment and scale, internal corrosion, internal grooving, defective riveting, thin tubes, pitted tubes, and leakage around tubes.

The foregoing are the defects usually found in boilers, and the inspector should be sure to discover all that may exist. Great care should be exercised when looking over a steam boiler. It is well to go over each detail of the back end a second time to make sure that nothing has been overlooked, before moving to the front to inspect that part of the boiler.

Turbine Troubles

It was Mr. Dooley who pointed out to the long-suffering "Hennessey" that there was no "news" in being good, and that what the public wishes to hear about were the doings of our social failures. A somewhat similar rule holds in matters mechanical. There may not be more joy over one turbine mishap than in the steady performance of their assigned task by 99 "just" turbines, but the occasional failure certainly excites much keener interest. This is not to be attributed (save perhaps in the case of trade rivals) to the certain joy, which the cynical French philosopher asserted, we all took in the minor misfortunes of our friends. As a matter of fact the "just" machine, which needs no amendment, teaches us very little, while much may often be learned from a breakdown. Of course, this rule does not invariably hold, since some accidents, as for example, the "Titanic" disaster, originate in an exceptional series of coincidences little likely to recur.

Much To Be Gained by Frank Publication

In general, however, a failure implies some weakness in design of material. It would be unsafe to assume that a "no trouble" machine had everywhere the same factor of safety, and it is the ordinary, not the exceptional, failure which shows us where margins have been cut too fine. From the technical standpoint much would be gained by the publication of full and complete details of machinery failures of all kinds, but this desideratum is seldom achieved save in official inquiries, which in some cases, however, are conducted by lawyers, who fail to bring out the really important points.

In general it is extremely difficult to get a plain unvarnished description of a mishap. This holds even when the trouble is of minor importance and when there is no intentional concealment. Those immediately concerned can hardly help forming some theory as to the accident and publish only such observations as are consonant with this.

American reports on steam-turbine failures have commonly been much more frank and open than it is usual for them to be in this country. Possibly the stricter interpretation which is placed here on the law of libel, may be a factor in the matter. Mr. Longridge used to publish annually most instructive reports on engine failures, but there are many more engine builders than steam-turbine makers, and hence the accidents on which Mr. Longridge commented could seldom be identified with any particular firm. Nevertheless, much information as to dangerous and safe types of construction has gradually become common property, and it is of interest to note, in the light of present knowledge, the excessively bad details illustrated in some of the early books on turbine construction.

Parsons Rule for Non-Lubricated Surface

It was Sir Charles Parsons who laid down the rule that if a non-lubricated surface is to move at a high speed in close contiguity to a fixed surface, one of the two must be merely a thin fin, so that if a touch occurs, wear might take place without any serious development of heat. The very serious accidents which have occurred from the bursting of turbine disks seems to indicate that turbine engineers might well take a leaf out of the book of the other great pioneer of turbine design, viz., Dr. de Laval. In general, no doubt, the designer aims at making his machinery with the same factor of safety throughout as the Deacon did in the case of the one-horse shay described by Oliver Wendell Holmes. In certain cases, however, this involves the risk that, like the shay, the machine may collapse "all at once and nothing first," an eventuality which has been very nearly realized in some of the accidents due to the burst wheels. Dr. de Laval avoided this risk by reducing the section of his wheel near the rim, thus providing a "breaking piece" which would insure that if failure did occur the fragments would be incapable of causing a general wreck.

A paper, in which the authors had collected together much interesting information on turbine failures, was read before the North-East Coast Institution of Engineers and Shipbuilders, on February 16 last, by Prof. A. T. Mellanby and Mr. W. Kerr. This was contributed by invitation with the idea of starting a general discussion on the whole subject, and in the hope that turbine builders might throw their own special experiences into the common stock. It cannot be said that this aim was altogether achieved, and no doubt trade interests must always conflict with such a counsel of perfection.

Nevertheless some highly interesting points were brought out both in the paper and in the discussion. The authors very appropriately classified breakdowns as blunders or mishaps, the former arising from a neglect of well-established principles and the latter being merely the inevitable accompaniment of the march toward higher and higher outputs, speeds and efficiencies. Steam temperatures and pressures have increased enormously of late years. At the beginning of the century the standard speed of a 3,000-kw. machine was 750 r.p.m., while today an output of 15,000 kw. has been obtained at 3,000 r.p.m. Pressures, too, have risen from less than 150 lb. per square inch at the beginning of the century to, in some cases, more than double this figure, and there has been an equally drastic rise in steam temperatures. An advance of this magnitude necessarily involves the transcending of experience, with the certainty that, in the language of the insurance market, some of the risks accepted would prove losses. Failures of this kind may reflect little or no discredit on the men who are bold enough to make the adventure. Such failures often pave the way to the next advance, though they may check progress temporarily. At present turbine builders seem inclined to reduce blade speeds in view of the disasters recorded, although in large modern machines blade speeds have never yet approached the figures which Dr. de Laval showed to be practicable a quarter of a century ago. The check is probably only momentary, as not only is there a steady increasing demand for still further reductions in the weight and cost of large units, but there is reason to believe that for high efficiencies blade speeds should either be very high or very moderate.—*Engineering.*

In order to regulate the load on the different boilers as intelligently as possible, it is important to determine the duty or rate of evaporation at which the boilers show their maximum efficiency when operating under given conditions. Until this is known, the number of boilers that should be used when carrying a given load is practically a matter of educated guesswork.

Peripheral speeds in early turbines, in one instance, were as high as fourteen miles per minute.

EDITORIALS

F. R. LOW, EDITOR

Pipefitters and Gas Engines

DURING the war it was by no means unusual to find the clerk in charge of the soldier classification cards placing meerschaum pipe makers and plumbers in the same list on the basis that all were pipefitters.

Equally absurd is the action of the Treasury Department officials in classifying internal-combustion engines under paragraph 399 of the Tariff Act instead of under paragraph 372. The former covers articles composed of gold, silver, platinum, etc., bearing a sixty per cent ad valorem duty, and has a basket clause which includes those not plated with gold, silver, etc. Into this latter class is placed the internal-combustion engine with a duty of forty per cent ad valorem, although this clause obviously was intended to cover small articles of the type commonly called art goods.

The Department states that the reason these engines are not taxed under paragraph 372, which covers steam engines, locomotives and other machines, is that while in the dictionary the term machine includes power-generating equipment, the internal-combustion engine in trade parlance is not called a machine. Inasmuch as this rather illogical ruling means an increase of thirty per cent in the duty, it would seem that the Treasury Department should consult some mechanical engineer on this particular point.

Making the Boiler Room a Desirable Place

IT IS only when an old power plant is replaced by a modern one that a true perspective of the difference between the two is obtained. One of these examples is given in the leading article in this issue. The old plant was probably almost as bad an example, both in layout of equipment and in operation, as could be found. On the other hand, the new plant is about as conveniently arranged for operation and cleanliness as a modern plant can be. The fact that the coal required by the old plant to produce a given quantity of steam has been reduced to less than one-half in the new station bears testimony to the operating conditions. These figures should set other industrial-plant owners and engineers that are operating old and inefficient equipment, to thinking about the possibilities of their own plants. The new installation was worked out and made under the direction of the operating engineering force of the plant. This undoubtedly has given both management and operating engineers a much better appreciation of the possibilities of their plant than they could have obtained otherwise.

An uncommon feature is the location of the coal bunker in a building separate from the boiler room. Although this is not the first time that the coal bunker has been located away from the firing aisle, it is not common practice. In this case there were engineering and financial considerations that dictated the arrangement. But, aside from these, there is the question of cleanliness and lighting in the boiler room. When boilers were hand fired and coal was delivered in front of the furnaces in wheelbarrows, the conditions were such as to promote dirt and grime and discourage trying to keep the place clean. Placing the bunker overhead and using mechanical stokers in well-designed plants has done much to remove the old unpleasant conditions. The ideal arrangement would appear to be to keep the bunker out of the boiler room entirely and bring the coal to the stokers in a weighing larry. In cities where property costs are high, the advantages gained are probably not worth the expense. Where cost is not a factor, there are many features that make keeping the bunker away from the firing aisle desirable, as discussed in the article. Sustained efficiency in plant operation can be maintained only by giving constant attention to the boiler room, and the more comfortable this part of the plant is made to work in, the easier it will be to attract the proper talent to this branch of operation.

The Transport of Coal

A LARGE factor in the present price of coal to a consumer is the cost of transporting it on the railroads from mine to furnace. This cost is proportionately larger for short hauls than for long hauls, for the cars in which the coal is carried are out of service for loading and unloading about the same amount of time in each case. At times the railroads have been so congested with freight that it was almost impossible to get coal shipments through. There is every indication that the natural growth of this country's business will place further burdens on the railroads in the near future.

With these thoughts in mind it would seem wise to consider every proposal that may offer a relief from such a contingency, particularly with reference to the transport of coal. It has been common practice for years to pipe natural gas from the gas fields of West Virginia as far as Cleveland, Ohio. Crude oil is piped from the Midwest fields to the Atlantic seaboard. These are examples of methods of fuel transport that have proved reliable and efficient and have imposed no burdens on our railroads. The success attained with these lines naturally has suggested the application of the principle of pipe transport to coal.

Some years ago a scheme was presented and discussed for transporting fine anthracite in pipes by flushing with water from Scranton to New York, but the system has never been built.

The successful transport of powdered coal in many plants by means of compressed air has suggested that this means might be employed to move coal over considerable distances in pipes. Compressed air mixed with the coal dust forms a fluid-like mass with the density and flow characteristics of fuel oil. A modification of this plan is to generate producer gas or byproducts gas at the mine and use it after compression as

the transport medium instead of air. Some engineers believe that this inert gas has advantages over compressed air.

Such systems present several obstacles. The initial delivery pressure of the mixture must be high, and owing to pipe friction this pressure will drop along the length of the pipe. A decrease in pressure would increase air volume, and therefore the pipe size must be progressively increased. At a certain point the pressure head will be exhausted and the mixture must be passed through a separator at a booster station. The air or gas must be recompressed and the flow in the pipe started over again. Lacking experimental data, it is difficult to estimate the distance that coal could be transported in this manner at various pressures. Hence, much development and experimental work remain to be done. While such pipe lines would relieve the railroads of much freight, it remains to be seen whether the transport of coal would be cheapened by this means.

In view of the increasing demand for the conservation of the byproducts of coal still another plan suggests itself. Let the coal be completely gasified at the mine mouth with the complete recovery of all byproducts. The resultant gas can readily be transported in pipes to the various consumers. The difficulty in this plan lies in the fact that heretofore it has been regarded as economical only to transport high heat-value gas over long distances. Large volumes of low heat-valve gas might prove uneconomical to pipe in this way unless at very high pressures.

All these proposed plans offer a possible solution to a perplexing and pressing economic problem. They can best be tried out in a small way by some of our larger utilities for whom their advantages might prove most attractive, particularly to those utilities near coal fields with short rail hauls and comparatively high freight rates. All these systems have been proposed as commercial undertakings, and it is apparent that engineers are giving careful study to the problems of coal transport.

Boiler Test Codes

THE CODE formulated in 1885 by a committee of the American Society of Mechanical Engineers for the testing of steam boilers which, with several revisions, has ever since been the standard of American practice, is undergoing another revision necessary to harmonize it with the developments of recent years.

On another page David Brownlie, the English author of a recent book upon boiler testing, criticizes the tentative draft of this revision. Much of Mr. Brownlie's attitude toward this Code in the communication under review and toward codes in general in his book arises from his practice. He is accustomed to making tests of boiler plants in daily operation to determine how well they are doing under the varying conditions of practice and what can be done to improve their performance. This leads him to argue for a severely practical code, more a set of rules for operation and observation and uniform accountancy than a codification of the observations to be made, the precautions to be observed and the line of calculations to be followed in determining with the required degree of precision some particular fact or group of facts about the performance of a boiler so that the results will stand the scrutiny of the profession or of a court.

For such determinations of continuous plant efficiency it is natural to wish to include all the phases through which the boilers pass, cutting in, straightway run, banking, etc., and the value of the week's check run which he proposes becomes apparent. "It seems to me, however," he says, "that the real, all-the-year-round performance of the plant, including light running, banked periods, and shutdowns at the week end, would be much more accurately determined by one inclusive week's trail than by the twenty-four hours suggested by the revised code."

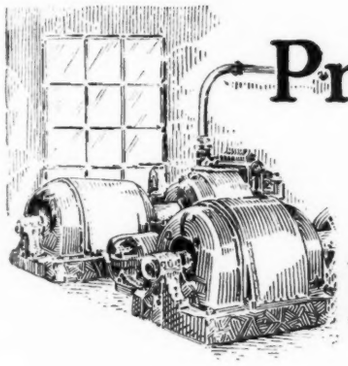
"The most serious effect" that he finds in the Revised Code is "the scanty attention given to the vital question of the amount of steam or power used auxiliary to the production of steam." This would be a grave omission in a handbook of rules for continuous industrial boiler-plant testing under the varying conditions of use; but the scant attention is quite sufficient in a code dealing with a short scientific test to determine certain characteristics of the boiler *per se*. With uniformity of observations once established, the efficiency of a boiler at a given rating or under other constant conditions can be determined in ten hours as well as a week, and its maximum capacity in a considerably shorter time. The minimum of ten hours is set so that any error in estimating the condition of the fire at the beginning and end of the test will be a minimized proportion of the total coal burned, and the Code provides that the test shall be continued until at least two hundred and fifty pounds of coal has been burned per square foot of grate surface.

The pertinency of much of Mr. Brownlie's comment will disappear when it is appreciated that the Code in question is designed to tell how an acceptance test shall be made so as to be fair to the maker and the purchaser of a boiler and satisfactory to a court, rather than to determine the year-in and year-out efficiency of a plant, although the processes outlined may be extended over a week or a year if desired. Simply it is unnecessary to require all tests to be supplemented by a week's check when their purpose can be adequately fulfilled in ten hours or less. The same consideration applies to the adaptation of the test to the working hours of the plant. If it is a plant test this will be necessary; if it is a test of a particular boiler it can be made at any time and run as long or as short as necessary.

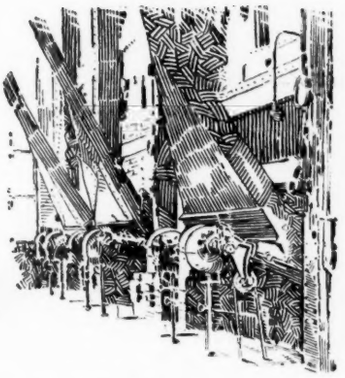
His proposal to correct the efficiency for the diminishing heat value of the fuel comes from the same point of view. In estimating the sustained efficiency of a plant for a long period or comparing efficiencies of plants with widely varying qualities of fuel, some recognition should be taken of the handicap, out of proportion to the smaller heat content of the fuel, that the plant using the low-quality coal is under, but here again it is a question of plant operation rather than scientific boiler testing.

We are glad to see him agree with the Code in its continued use of the high testing value. The code of the Civil Engineers, the only code that has any recognition in English practice, favors the lower heat value, which has led to some confusion in comparing tests made here and in Great Britain.

Four of the big power companies are figuring on employing steam pressures of one thousand pounds or more. This is a big jump, but should not prove very troublesome if the temperatures are held within reason.



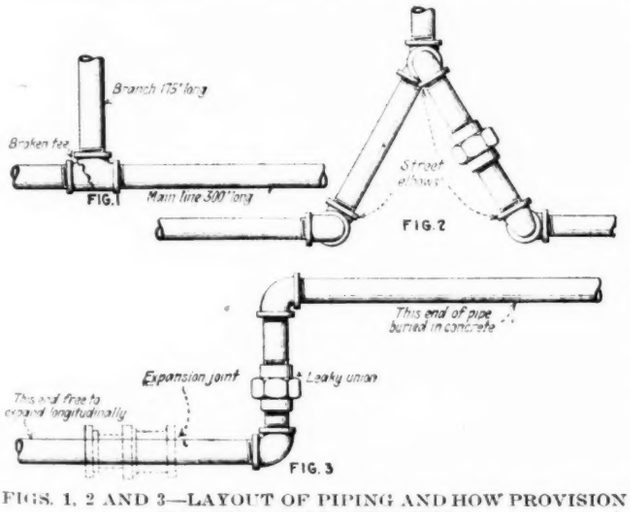
Practical Ideas *from* Practical Men



Problems of Expansion

Almost every engineer is familiar with the rules and laws of the expansion of iron and steel, especially as applied to steam pipes and boilers, as this is the type of equipment with which he is most familiar. However, few of them pay much heed to these rules when installing pipe lines; especially the smaller sizes. I recently experienced some difficulties in this line myself, and admit that I had never before given much thought or consideration to the subject of expansion.

I was in charge of a sanatorium consisting of one central building and a number of bungalows scattered over a large area of ground. There was a central heating plant which supplied steam heat and hot water for all the buildings. The hot water was supplied by a 1,000-sq.ft. horizontal return-tubular boiler, used as a hot-water heater and fired with gas. Cold water from the city mains under 60 lb. pressure entered an auxiliary closed heater, where it was heated to a certain extent with exhaust steam and then fed to the boiler,



FIGS. 1, 2 AND 3—LAYOUT OF PIPING AND HOW PROVISION WAS MADE FOR EXPANSION

where the temperature was raised to around 180 deg., depending on weather conditions.

Some of the hot-water lines to the bungalows were a quarter of a mile long, and with the two lines, outlet and return, the heat loss was considerable.

The hot water was circulated by a motor-driven centrifugal pump. At eight o'clock at night the fire was shut off under the boiler and the pump stopped, as there was little hot water used later than this and the storage capacity of the boiler was sufficient to supply all that was needed during the night.

Soon after taking charge of this plant, I was greatly troubled by the bursting of hot-water pipes and fittings. At first I naturally supposed that the trouble was due to the age and poor condition of the pipes, which had been installed underground for about fourteen years, and were corroded badly in some places. As the leaks developed, sections of the lines were replaced with new galvanized pipe. However, when this was accomplished we soon found that our problem was still unsolved.

In two particular instances, as shown in the illustration, we were troubled with broken fittings. Fig. 1 shows a long line of hot-water pipe with a branch running at right angles. Both the main and the branch line were buried about two feet underground. In this case it will be seen that the branch line acts as an anchor, preventing longitudinal expansion of the main line. At this point we first supplied the junction of these two pipes with a heavy cast-iron tee, and a few days later it was broken, so we tried malleable-iron and extra-heavy fittings with the same results. Finally, we decided that the trouble must be caused by expansion and contraction of the pipe lines, due to the fact that the hot-water pump was shut down at night, permitting them to cool down, and then started in the morning when water at 180 deg. was circulated through the pipes, causing them to expand. As no provision was made to take care of the expansion, the constant strain eventually caused fatigue of the metal and the fitting would burst.

As we had no expansion joints or couplings in stock and it would require some time to secure them, and the line had to be repaired immediately to supply some of the buildings with hot water, we decided to construct an expansion joint as shown in Fig. 2, with the pipe fittings that were on hand. After this was installed, we had no more trouble with broken pipes or fittings on this line.

Fig. 3 shows another length of piping fitted with an offset and union, which gave considerable trouble, due to expansion and contraction. The line at one end of the offset was free to expand, while the other was stationary. The offset and union were buried about three feet underground. One day a bad leak appeared at this point, and upon examination we found that the gasket had blown out of the union. We replaced the gasket with high-pressure rubber, suitable for this service, and filled up the excavation with dirt. About two weeks later the leak recurred. Again we excavated and found the same trouble—the gasket was blown. We excavated four or five times, repaired the leak and filled in. We tried every kind of gasket, also a ground-joint union, to no avail. Later we discovered that the leak always occurred in the early morning, immediately

after the hot water started circulating. We concluded that the trouble must be due to expansive forces which twisted the union out of line and caused it to leak. To overcome this we installed an expansion joint as shown dotted in Fig. 3, and our troubles from this source were ended. R. L. TULLIS.

Monrobia, Calif.

Changes in Piping Reduce Trouble and Cost of Repairs

Frequently, small changes in piping and the arrangement of valves make a considerable change in the economical and convenient operation of the plant, and there is no part of the plant that is more important, or

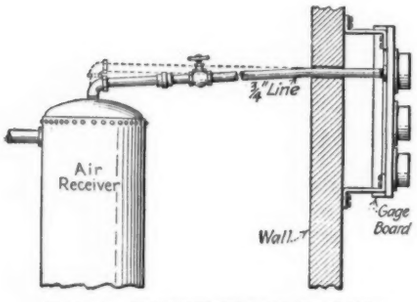


FIG. 1—SLIGHT SLOPE IN LINE PREVENTS FREEZING

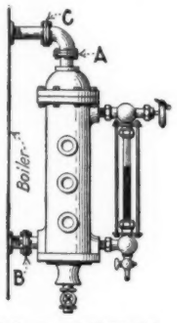


FIG. 2—COLUMN AND CONNECTIONS

that can give the operator or repair-man more satisfaction than the thoughtful arrangement of the piping.

The first winter that I worked in a certain plant, the air line from the receiver to the gage board and governors on the air compressors would frequently freeze up, causing considerable trouble. This was overcome by removing a ¾-in. nipple and elbow and replacing them with a street elbow, as shown in Fig. 1, so that there was a slight slope in the line from the wall of the building to the receiver; then any moisture collecting in the line would drain back into the receiver. In the two winters that have passed since this change was made, no trouble has been experienced with freezing up.

Another source of trouble was found in the boiler connections to the automatic feed-control columns on the vertical boilers. They had a horizontal flange *A* in the top pipe connection and a vertical flange *B* in the bottom connection. To do any work on or in these columns, it was necessary to take the whole column down. By placing a vertical flange *C* in the top pipe, as shown in Fig. 2, the top part of the column could be easily and quickly removed in making repairs to the float mechanism. J. V. EMERY.

Struthers, Ohio.

Purging of an Ammonia Condenser

The general rule for purging a condenser is to stop the compressor and continue to run water over the condenser for half an hour or so before opening the purge cock. Frequently, after doing this the engineer feels that there is still in the coils a lot of air which refuses to come out.

In allowing water to flow over the condenser, it is by no means unusual to find the water leaving the condenser colder than when going into the coil. This is due to evaporation which goes on as the water splashes from coil to coil.

In order to trap the air for purging, it is necessary to cause it to flow to some particular portion of the condenser. Air flow will set up only when the ammonia is condensing more freely in this particular part of the condenser. This requires that this portion of the coil must be colder than the remainder. Consequently, if the top pipes are colder than the other coils, the air will flow up, and as the ammonia temperature is lowest here, the pressure due to the ammonia will be lower here than elsewhere, making the percentage of air in the mixture greater in the top coils than lower down.

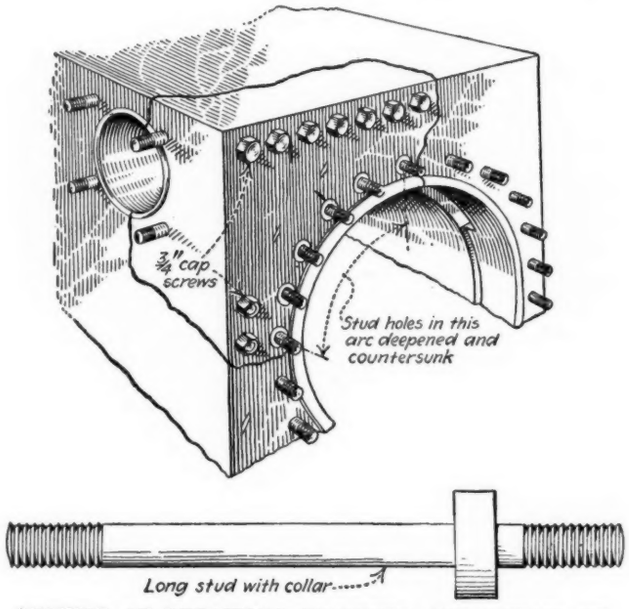
To cause the top coils to be the lowest in temperature, splash boards may be placed on about the third coil, so that the water, after leaving the top two coils, does not strike the coils lower down. The water evaporation with the resulting cooling of the water will not lower the temperature in the lower pipes. Where there are more than two stands, it is advisable to use one stand for the trap. M. H. MILLS.

St. Louis, Mo.

Repair of Fractured Cylinder Casting

The sketch shows how the cylinder casting of a Corliss engine was repaired after a corner of the casting had been broken. The damage had resulted from the breaking of the crosshead, which left the piston free to knock out the head.

A number of holes were drilled through the broken part along the upper and side edges of the casting. These holes were sunk far enough beyond the fracture



METHOD OF REPAIRING CYLINDER, AND DETAIL OF SHOULDERED STUD

to give a good threadhold in the main part of the casting. They were first drilled to a diameter of $\frac{31}{32}$ in. to allow for tapping to receive ¾-in. cap screws, and were then bored to a diameter of $\frac{13}{16}$ in. as far as the fracture, so as to give clearance for the shanks of the screws. The cylinder-head studs were removed from the fracture part and the holes were drilled and tapped to give a threadhold beyond the fracture. A square-shouldered countersink was bored in each of these holes, and long studs with collars on them to fit into the countersinks, were screwed in.

After the capscrews and the collared studs had been pulled up tight, a dovetail groove was chipped along each of the cracks, and a piece of ¼-in. copper wire was annealed and calked into it. A. J. DIXON.

St. Louis, Mo.

Peculiar Behavior of Direct-Current Motor

On being called to locate trouble in a small direct-current motor, I found that it would start all right when the contact arm of the starting rheostat was held

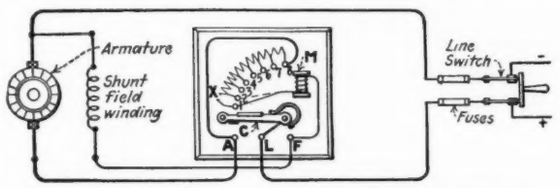


FIG. 1—DIAGRAM OF CONNECTIONS OF SHUNT MOTOR TO STARTING RHEOSTAT

upon the first contact buttons, but would stop as soon as the arm was advanced farther, and then, after the resistance was nearly all cut out, it would start again, but in a reversed direction, and quickly reach a dangerously high speed and spark badly. It was also found, after further investigation, that the motor would not start when the contact arm was held on the first contact alone, but would start when the arm bridged the first and second contacts and then would stop when the arm left the first contact. This, of course, suggested a break in the resistance coil connected between the first and second contact buttons.

On taking the starting rheostat down and opening it up, I found this resistance coil to be burnt out and open-circuited as shown at *X* in Fig. 1. As the field circuit was connected through the retaining magnet to the first resistance contact, as in the sketch, the field would be opened when the arm was moved off the first contact and leave only the armature in circuit. To repair the fault, the wire that leads from the retaining magnet *M* to the resistance was disconnected from the

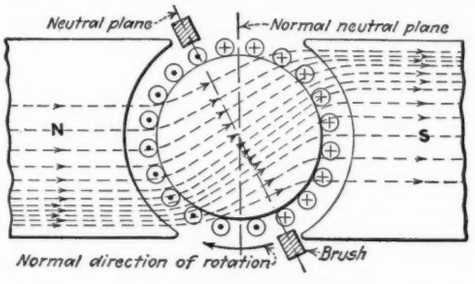


FIG. 2—DIAGRAM OF MAGNETIC CONDITIONS IN MOTOR WITH FIELD CIRCUIT CLOSED

first contact and connected to the second, as shown by the dotted line.

The reversal and overspeeding of the motor can be explained by reference to Figs. 2 and 3, which represent the magnetic conditions of the armature and field poles with normally excited and open-circuited fields respectively. Fig 2 shows the field distortion caused by armature reaction and also the brushes shifted backward against the direction of rotation, as is generally necessary in non-interpole motors to obtain sparkless commutation. Fig. 3 shows the magnetization due to the armature current alone when the field circuit is opened. Note that, due to the position of the brushes, the effect of the armature current is to set up a magnetic field, which, throughout the greater part of the poleface, is just the reverse of that of Fig. 2.

When the contact arm was moved off the first contact, thus breaking the field circuit and stopping the

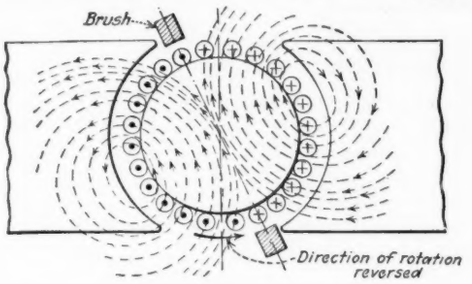


FIG. 3—DIAGRAM OF MAGNETIC CONDITIONS IN MOTOR WITH FIELD CIRCUIT OPEN

motor, the magnetic conditions were changed from those of Fig. 2 to those of Fig. 3. This field would not, at first be strong enough to cause the motor to start, but as resistance was further cut out and the armature current and its magnetizing effect increased, sufficient reversed field strength would be built up to cause the motor to start again in a reversed direction. And owing to the weak field and also to the fact that it then had the speed characteristics of a series motor, it would, without load, quickly reach a dangerous speed. In this instance the starting rheostat had been used for speed control and the burnt-out resistance coil was the natural result. H. G. ROBERTS.

Seattle, Wash.

Safety Device Out of Commission Causes Fatal Accident

Many accidents occur in power plants from neglect to keep in proper adjustment or operation the safety devices with which the different pieces of equipment are fitted. What happened recently in a neighboring plant may serve as a warning to those operating similar equipment.

The plant contained two boilers, one of which is fired by a chain-grate and the other by an underfeed stoker. The ash and clinker from both stokers are dumped into a trench at the rear of the grate, and are conveyed into a hopper in the yard, by a steam-jet ash conveyor. The dump plates on the underfeed stoker are operated by steam cylinders. The cylinders are equipped with a safety device that prevents the pistons from moving if the throttle leaks or is accidentally opened by someone.

The boiler that is fired by the underfeed stoker had been out of service for cleaning and was being steamed up again, when, because the safety devices were not in place, and the throttle valve was either leaking or partly open, admitting steam into the cylinder, the refuse on the dump plates was discharged into the ash trench, burning a man who was removing the ashes from the other boiler so badly that he died about five hours later. It is reported that the safety device was accidentally knocked out of place by one of the boiler-room laborers. However, the dumps would not have operated had not the throttle been leaking.

Henderson, Ky. JOHN MACONNELL.

Comments from Readers

Care of Gas-Engine Igniters

In the operation of gas engines engineers sometimes make a practice of replacing stuck igniters when the engine is running, the load being carried by the other cylinders. This practice is certainly not advisable and may cause a shutdown if the remaining cylinders cannot carry the load.

Sticking of the movable electrode can be prevented by allowing about $\frac{1}{16}$-in. endwise play and by feeding occasionally a small quantity of heavy gasoline to the stem of the electrode. On the suction stroke of the engine the electrode stem and its bushing are separated by reason of the pressure difference between the outside and inside of the cylinder and the gasoline spreads evenly over the stem. If desired, the liquid may be fed to the igniters by means of slightly compressed air. The tension of the spring that holds the tip of the movable electrode against the stationary electrode should be adjustable in order to compensate for wear of the different parts and to break the current as effectively as possible. This is very important when starting the engine. H. WIELAND LOS.

Schoonhaven, Holland.

Trouble with Misaligned Engine Shaft

Mr. Shepherd's article on crankshaft alignment in the March 6 issue recalls an experience I had with one some years ago. In 1902 the company I was with installed two 125-hp. three-cylinder vertical gas engines. A high-pressure triplex power pump was direct-connected on each end of the crankshaft of each engine. The engines were received from the makers with the shafts in place and were erected by one of our mechanics.

Each engine had two flywheels, and one wheel on one of the engines never ran true and had a slight jump to it. Some five or six months after the engines were put in service, the shaft of this engine broke in the outside bearing next to the faulty flywheel. There was some controversy with the makers over whether they should replace the shaft gratis or not, but they examined the fracture and could find no fault in the metal.

A new shaft and a new bottom brass for the bearing were received and installed by another machinist, and the flywheel acted as before. The machinist explained to the superintendent that it would wear in after a while.

I was always skeptical of the "wearing in" method, so one day I asked the old chief if I might try to locate the trouble. He told me to go as far as I liked, so I shut the engine down, released the clutch on the side next the eccentric flywheel and, turning the flywheel on different quarters and plumbing it, found it showed perfectly true when at a standstill. I then started the engine and disengaged the igniter rod on the middle cylinder, causing this cylinder to miss, but this did not change the jumpy running of the flywheel. But when I put that cylinder back to work and threw out the cylinder next the flywheel, the latter immediately began to run true. We put about a $\frac{1}{16}$-in. shim under the bottom brass in the bearing next to flywheel and had no further trouble. The engine is still in use and according to all reports has never had any more shaft trouble. The difficulty was evidently due to misalignment of this bearing. F. E. MYERS.

Charleston, W. Va.

Large Percentage of Impurities Passes Over with the Steam

I read with interest the article by J. F. Hobart on boiler inspecting in the Feb. 27 issue. He makes one statement, however, that is somewhat misleading when he says, "But bear in mind that impurities contained in the feed water are never carried off with the steam." This is decidedly contrary to my experience. I have found that considerably more than half of the dirt in the boiler feed passes over with the steam. In many cases the proportion of the solids in the feed which go out with the steam is 90 per cent, or more.

I have compiled considerable information and data on this subject in the way of theoretical figures and actual examples of enormous amounts of dirt passing out of the boiler with the steam, and will admit that I was surprised myself, when the amount passing to the steam header showed so high. O. R. MCBRIDE.

Chicago, Ill.

What Causes Tubes to Blister with Oil Burning?

In answer to C. W. Hill's request in the March 27 issue for information on the cause of tubes blistering when burning oil under boilers, I offer the following information and suggestion:

From the description and illustration of the furnace it would appear that the boiler is operated with too much draft. Excessive draft will cause the flame to lift as soon as it leaves the burner, and it will reach the tubes before combustion has been completed. If the mixture of fuel oil and air is in such proportions as to produce a long white flame instead of a yellow one, tube trouble is bound to follow.

To correct this condition, the following suggestions are offered: Install an inspection door in the side of the Dutch oven large enough to permit a good view of what takes place inside the furnace, reduce the draft and oil until a yellow rolling flame fills the furnace. Complete combustion should take place in the furnace, and only the products of combustion should touch the tubes. Maintain only sufficient draft to carry the products of combustion through the boiler to the stack and avoid shutting the damper entirely.

I am familiar with a plant operating a group of 3,000 sq.ft. water-tube boilers equipped with Dutch-oven furnaces, burning fuel oil producing 135 per cent of rating with 0.20 in. draft at the uptake.

Hillside, N. J. G. W. HERLICK.

Vibration in Small Direct-Connected Units

In the March 13 issue, H. M. Phillips, in an article on "Vibration in Small Direct-Connected Units," discusses in detail the question of rigid versus flexible couplings.

A rather broad statement is made in saying that a flexible coupling produces reciprocating strains when running out of line. It is quite true that many flexible couplings do have this objectionable feature, but I am familiar with a type which does not present this difficulty and which has been used with a great deal of success on extremely high speed units and also on heavy-duty drives. I have seen this coupling in operation under conditions that would prove disastrous to other types. It is possible that Mr. Phillips is not familiar with this coupling.

I cannot agree with his statement that a unit with a flexible coupling is more likely to give trouble than one with a solid coupling. If difficulty is occasioned, owing to a unit's being out of line when using a flexible coupling, the troubles will be infinitely greater if the unit is out of line when using a solid coupling. I do not know of any manufacturer who does not consider it highly essential that as much care be taken with the installation of a flexible coupling as would be taken with a solid coupling. The mere presence of a flexible coupling should not be taken as an excuse for faulty erection. If it were absolutely possible to maintain three or four bearings in line indefinitely, there would be no excuse for a flexible coupling. The mere fact that misalignment does take place, has brought into use the flexible coupling and has been responsible for its development.

H. R. GEIGER.

New York City.

Advantages in Having Competent Oil-Engine Operators

Refinements in design and better workmanship and materials have worked wonders in the last ten years in internal-combustion engines, and the efficient, reliable and satisfactory operation in recent years of the several types of oil engines under various conditions of service have proved their merits to the most skeptical. But no mean part of the oil engine's success is due also to a better understanding on the part of the operating engineers of the principles involved.

The most enthusiastic oil-engine advocates must admit that the records of a large percentage of the early units were far from enviable. However, there were occasional outstanding exceptions. I contend, as do many others, that in spite of the shortcomings of the oil engines of the vintage of 1900 to 1910, the fault of their unsatisfactory performance lay as often with the operator as with the machine.

In the town where I was raised, the first engine installed in the light plant was a low-compression, two-stroke-cycle, hot-bulb affair made by one of the early oil-engine manufacturers in this country. This was operated for the first four years under the supervision of the man who installed the plant, and from this man I got my first oil-engine experience. In 1911, after finishing college, I returned as manager of this plant, which had grown much larger, but this first engine was still in daily service and continued in service until 1914, when the plant was closed down and current purchased from a transmission line.

During the seven years' operation of this engine, and it ran from 7 to 14 hours nearly every day of that time, the repairs consisted of a few fuel-pump parts and hot-bulbs, two sets of piston rings, two crankpin bearings and one set of main crankshaft bearings. When the plant was closed down, it was still in fair condition and was sold to another plant, where it is still in use.

In marked contrast to the performance of this engine was the record of identical engines installed about the same time in a plant in a nearby town. This plant was always in trouble. After a few years' operation, it looked as if there were enough broken cylinder heads, broken and scored cylinders and pistons and other discarded parts in the junk pile to fill a freight car. After about four years of grief, this plant was abandoned and replaced by steam. From personal knowledge of the plant and its operators I know that the principal cause of the trouble and expense was the lack of competent operators.

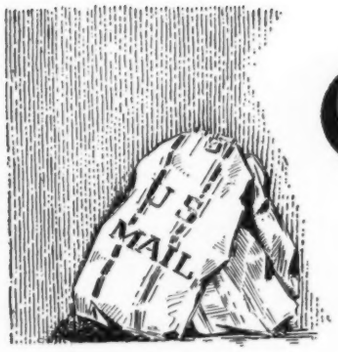
I had a later experience in 1919, illustrating the desirability of competent engineers, when I accepted a position as superintendent of a municipal water and light system. This plant had two four-stroke-cycle air-injection engines that had been installed about 1911 and one larger engine of the same make installed in 1917. The history of this plant from its beginning had been an almost unbroken record of misfortune. Broken cylinder heads, scored pistons and cylinders and broken crankshafts, one of which almost totally wrecked an engine, for the cylinder heads, air compressor, cylinder liners and flywheel were practically all that was salvaged. It was a common occurrence in this plant for three units to be broken down completely.

Fortunately for me, a short time before I took charge a new chief and first-shift engineer had been employed, both of whom I found to be thoroughly competent men. In the course of a few months we had that plant in such condition that a shutdown was as rare an occurrence as continual service had formerly been. A few weeks ago I visited this plant and found those old machines operating faithfully and satisfactorily, doing all that can be expected of engines of their age and design. Incidentally, the chief and the first shift engineer who put this plant on its feet are apparently appreciated and are still on the job at salaries above the average paid for similar positions in that part of the country. And it is sound business for that plant to pay good salaries to keep them or other competent men. Those men have saved many times their salaries in reduced operating and maintenance expense compared with the times before they were there, to say nothing of the good service the plant now gives.

In my opinion the engine manufacturers, or at least their salesmen, have been somewhat to blame for the unsatisfactory service of some of the engines. One of their heavy talking points in making sales has been that "anybody can run our engines." Too often after the sale is made the purchaser accepts that statement at its face value to both his and the manufacturer's subsequent sorrow. My observation has been that where oil engines have been properly operated and cared for, they have been generally satisfactory. Even the old timers, with competent engineers in charge, have given service that has been little less than marvelous, considering the more or less imperfect design compared with modern standards.

J. H. BENDER.

Crosbyton, Tex.



QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Mechanical Stokers for Scotch Marine Boilers

Why are not chain-grate stokers adapted to the Scotch marine type of boiler? J. D.

The principal obstacle in the way of a chain-grate stoker with a Scotch marine type of boiler is the necessity for arches with that type of stoker and the difficulty of cleaning and getting rid of the ashes. Indications are that some form of stoker in which the coal is sprinkled or ejected into the furnace would be most adaptable. Stokers of this kind have been built abroad, and American locomotive builders are experimenting with this type for locomotives.

Mean Effective Pressures in Semi-Diesel Engine

Why may the mean effective pressure of a semi-Diesel engine using water injection be higher than in case of a "dry" engine? R. S. P.

The water tends to cool the piston head and cylinder contents so that the actual weight of air trapped into the cylinder is greater than in a "dry" semi-Diesel where the initial compression temperature may run very high. The cooler air charge keeps down the final compression temperature as well as the maximum ignition temperature and permits the combustion of a larger amount of fuel before the cylinder temperature becomes excessive. This increases the mean effective pressure.

In addition, the water vapor or superheated steam in the cylinder, does not drop as rapidly in pressure as the combustible gases. By absorbing heat from these gases early in the stroke and giving this heat back during the later part, the steam serves to keep the m.e.p. higher than otherwise would be the case.

Cause of Voltage Drop on Generator

On a motor-generator set consisting of 1¾-hp. 220-volt 60-cycle alternating-current motor directly connected to a 1-kw. 39-volt compound-wound direct-current generator, trouble has been experienced with the voltage decreasing after the machine has been running for a time. When first started, the voltage is adjusted to 40 volts by the field rheostat, and although the current is held constant at about 20 amperes charging a storage battery, in about one hour the voltage drops to 37. What is the cause of this drop in voltage? P. V. E.

This trouble is due to the resistance of the generator's armature and field circuits increasing with the temperature. When the machine is started cold, the resistance of the windings is at a minimum, but as the temperature increases, due to the load, the resistance of the armature and field coils increases. The increase in field-coil resistance causes a decrease of current in this circuit much the same as cutting the field rheostat into the circuit, thus reducing the field strength and voltage of the machine.

The increase in the temperature of the armature copper will cause an increase in voltage drop through the armature windings, but this to a degree is compensated for by the decrease in resistance of the brushes, since the resistance of carbon decreases as its temperature increases. However, in a low-voltage machine the brushes generally have a considerable percentage of copper in them, which will tend to neutralize the effects of the negative temperature coefficient of the carbon. Consequently, a greater decrease in voltage at the brushes might be expected than with straight carbon or graphite brushes.

If the generator were driven by a direct-current shunt motor, the motor speed would increase with the temperature of its winding and tend to compensate for the voltage drop in the generator. The speed of an induction motor will be practically constant if the frequency of the supply circuit is maintained constant; if anything, the speed will decrease slightly with an increase in temperature and constant load. Any decrease in the motor's speed will cause a decrease in voltage of the generator.

Number of Expansions with Given Cutoff

What is the number of expansions taking place in the cylinder of a steam engine when cutoff takes place at ⅜ of the stroke? E. G.

The number of expansions is the number of times the whole final volume of steam present in the cylinder at the end of the stroke would contain the volume of steam in the cylinder at the time when cutoff takes place. If there were no clearance and cutoff at ⅜ of the stroke, then the number of expansions would be $1 \div \frac{3}{8} = \frac{8}{3}$; or 2.66 expansions. However, there always is some clearance or waste space in the end of the cylinder and steam passages from the piston back to the valves in the beginning of the stroke, which is in addition to the volume displaced by the piston, and that space must be part of the volume of initial steam that is present at the time cutoff takes place, and also part of the final volume of steam present when the engine has reached the end of its stroke. Hence, if the clearance volume is 5 per cent of the volume displaced per stroke of the piston, and cutoff takes place at ⅜, or 0.375 of the stroke, the actual initial volume present at cutoff would be $0.375 + 0.05 = 0.425$ of the piston displacement per stroke, the final volume would be $1 + 0.5 = 1.05$ times the volume of piston displacement per stroke, and the actual number of expansions would be $1.05 \div 0.425 = 2.47$.

Thermometers Influenced by Approximity to Room Walls

Will a thermometer that is hung about a foot from a wall register the temperature of the air surrounding the thermometer? If not, what is the explanation?

M. M.

The temperature of a wall is never quite the same as that of the air on one side of it. Either it is allowing heat, however small, to pass in or out of the room. Its temperature is then either higher or lower than room temperature.

Assume the wall is at a temperature below that of the air. When a thermometer is hung in the vicinity of such a wall, there is some radiation from the thermometer to the wall. There will be a transfer of heat from the air to the thermometer, but up to a certain point the thermometer will radiate more heat than it receives, and as a result the registered temperature will be below that of the air; often the difference is several degrees. Since a highly polished surface radiates less heat than glass, if the bulb is covered with gold or silver leaf, the thermometer will register within 2 per cent of the real temperature.

Cippoletti Trapezoidal Weir

What is the Cippoletti or trapezoidal form of weir, and for use as a module to measure a flow of water, what are its advantages over a rectangular notched weir?

R. L. S.

With a sharp-crested weir, Fig. 1, contraction of the discharged stream of water occurs at the crest. The under surface of the falling water rises, as it leaves the sharp crest a just as for a sharp-edged orifice.

Where from the form of the sides, as at a in Fig. 2, there is no end contraction, as shown in plan at a, Fig. 2A, the discharge in cubic feet per second for the head am, Fig. 1, is

$$3.33 \times \left\{\begin{matrix}\text{length } a\,a \text{ of the} \\ \text{overfall in ft.}\end{matrix}\right\} \times \sqrt{\begin{matrix}\text{cube of the} \\ \text{head } a\,m \text{ in ft.}\end{matrix}}$$

or as commonly quoted

$$(1)\quad Q = 3.33\, lh^{\frac{3}{2}}$$

where

Q = flow in cubic feet per sec.,
l = length $a\,a$ in feet,
h = head $a\,m$ in feet.

For a rectangular notch with a sharp crest and also vertical sharp edges like $a\ s$, Fig. 3, end contraction occurs as at a Fig. 4, as well as at the crest aa, Fig. 3, and the discharge is decreased by about 0.1 of h, Fig. 1, for each contraction. Hence where there is contraction at both ends the formula (1) has to be modified to the form,

$$(2)\quad Q = 3.33(1 - 0.2h)h^{\frac{3}{2}}$$

In the Cippoletti trapezoidal weir, instead of having the ends vertical they are inclined outward as shown in Fig. 5.

Water which passes through the two triangles abc, Fig. 5, for each head, may compensate for the loss caused by lateral contraction. Cippoletti assumed that when employed within the range of lengths l and depths h necessary for discharging quantities required of the module proposed by him for the Villoressi canal, Province of Milan, Italy (1881), with the ends of the rectangular form spread apart so as to give each an inclination of 1 horizontal to 4 perpendicular, as indicated in Fig. 5, the proposed module could be relied upon for accuracy within $\frac{1}{2}$ of 1 per cent, using the simple formula (1).

A. D. Flinn and C. W. D. Dyer (*Trans. A.S.C.E.*, Vol. 32, 1894) in experiments with this form of weir have determined that with variable degree of contraction due to different heads, exactness within $\frac{1}{2}$ to 1 per cent is realized only under a limited range of proportion of head to the breadth l, and for velocities of approach not exceeding $\frac{1}{2}$ foot per second; but no more serious error than 2 per cent under ordinary conditions.

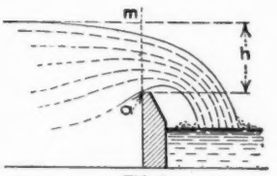


FIG. 1

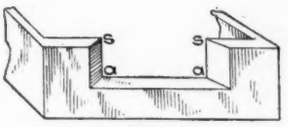


FIG. 3

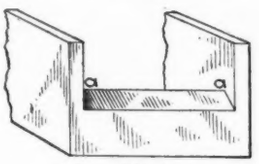


FIG. 2

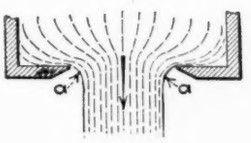


FIG. 4

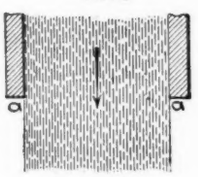


FIG. 2A

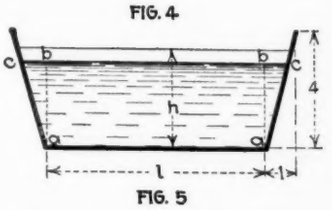


FIG. 5

FIG. 1—CROSS-SECTION OF SHARP-CRESTED WEIR. FIG. 2—WEIR UNCONTRACTED AT THE ENDS. FIG. 2A—PLAN OF FLOW OVER WEIR LIKE FIG. 2. FIG. 3—WEIR WITH SHARP EDGED RECTANGULAR NOTCH. FIG. 4—PLAN OF FLOW OVER WEIR LIKE FIG. 3. FIG. 5—FORM OF CIPPOLETTI TRAPEZOIDAL NOTCH

Hence, as a module the trapezoidal form of weir possesses superior practical advantages over the rectangular form, since it requires only a simple set of coefficients for flow in cubic feet per second for various values of h per foot in length of sill, and which will be applicable to all length of weirs regardless of proportion of head.

Turbine Efficiency with Different Vacuums

Is a steam turbine equally efficient under the rated conditions of 185 lb. gage steam, 100 deg. superheat and 28-in. vacuum as at test conditions of 180 lb. gage, 90 deg. superheat and 28-in. vacuum?

C. M. U.

If the turbine was built for 29 in., yet the guarantee was on a basis of 28-in. vacuum, it would be slightly more efficient on the 29-in. vacuum and should show a water rate of 6 to 7 per cent better than 28-in. However, if this machine was built for only 28-in. vacuum, it would in all probability be much less efficient at 29-in. and, at least, would convert considerably less than 6 per cent energy of the steam on account of the extra inch of vacuum.

[Correspondents sending us inquiries should sign their communcations with full names and post office addresses.—EDITOR.]

Easy Lessons in Engineering

How to Interpolate

Many engineering computations are based on tables. The ability to use these quickly and accurately is an essential part of the mental equipment of any engineer. Some tables give all the values that will be encountered in practice. Others such as square and cube roots, areas of circles, etc., can give only a series of values separated by small jumps. Sometimes it is possible to make these jumps so small that the nearest value in the table is always close enough. Very often, however, limitations of space make this impossible. In such cases it is important to know how to "interpolate."

To interpolate means to read between two sets of values in the table. As an example, suppose that we have a table of cube roots and want to find the cube root of 156.7. This does not occur in the table, the nearest values being the whole numbers 156 and 157. This part of the table reads as follows:

Number	Cube Root
156	5.3832
157	5.3947

Now imagine the given number 156.7 and its unknown cube root (which for the present may be represented by A) slipped into the table. We then have

Number	Cube Root
156	5.3832
156.7	A
157	5.3947

Evidently, the value of A must be between 5.3832 and 5.3947. Moreover, the successive values are so close that it may be assumed without appreciable error that if the number increases steadily from 156 to 157, its cube root will increase steadily from 5.3832 to 5.3947. The total increase in the number on going from 156 to 157 is 1. During the same period the cube root increases 0.0115, the difference between 5.3832 and 5.3947. The change from 156 to 156.7 is seven-tenths of the change from 156 to 157. Hence the change in the root must be $0.7 \times 0.0115 = 0.00805$. Since it is not worth while to carry this to more places than the table, it should be written 0.0081. The correct value for the cube root of 156.7 must then be $5.3832 + 0.0081 = 5.3913$.

In general, interpolation is an accurate procedure. The exception to this statement occurs when the difference between two successive values is large in comparison with the numbers themselves. For example, the steam tables show a temperature of 101.8 deg. F. for a pressure of 1 lb. absolute and 126 deg. for 2 lb. To interpolate for the correct temperature at 1.6 lb. would give a temperature of 116.4, whereas the true value should be 118.1. This, however, is an extreme case only rarely found in practice.

A somewhat more difficult case of interpolation is found in the following example. It is desired to find the volume of one pound of steam at an absolute pressure of 1.2 in. of mercury. The steam tables available do not contain any table reading directly in inches of mercury. There is, however, a table made for even degrees of temperature, but containing columns for inches of mercury and for volume. The nearest figures in the table read:

Inches of Mercury	Volume
1.171	562.9
1.209	545.9

Taking the upper lines as the starting point, we find that the pressure increases 0.038 in., while the volume *decreases* 17.0 cu.ft. For a pressure of 1.2 in. the increase is $1.200 - 1.171 = 0.029$ in. which is the fraction $\frac{0.029}{0.038} = 0.764$ of the total. Therefore the volume should, at the same time, decrease the same fraction of the total, or $0.764 \times 17.0 = 13.0$ cu.ft., so the answer must be $562.9 - 13.0 = 549.9$ cu.ft.

Occasionally, a problem requires what is called "double interpolation." Suppose, for example, we want the total heat of steam at 252 lb. absolute and 146 deg. superheat. The nearest pressures in the superheated steam tables are 250 and 255 lb., while the nearest superheats are 140 deg. and 150 deg. The layout then corresponds to the following:

	140 Deg.	150 Deg.
250 lb.	1,283.7	1,288.8
255 lb.	1,284.2	1,289.3

All we can tell at a glance is that the desired total heat lies between the extreme limits of 1,283.7 and 1,289.3 As a first step we may imagine the following layout, where C is the desired answer and A and B are intermediate steps:

	140 Deg.	146 Deg.	150 Deg.
250 lb.	1,283.7	...	1,288.8
252 lb.	A	C	B
255 lb.	1,284.2	...	1,289.3

The first step is to get A and B. A is 1,283.7 plus 0.4 of the increase from 1,283.7 to 1,284.2. This gives $A = 1{,}283.7 + 0.4 \times 0.5 = 1{,}283.9$.

In the same way $B = 1{,}288.8 + 0.4 \times 0.5 = 1{,}289.0$.

We now may write

	140 Deg.	146 Deg.	150 Deg.
252 lb.	1,283.9	C	1,289.0

So the final value of the total heat will be

$$1{,}283.9 + 0.6 \times 5.1 = 1{,}287.0$$

This process of double interpolation, while easy to understand, is cumbersome to apply and should be avoided where possible.

One of the most important applications of interpolation is in connection with logarithms. In fact, interpolation is practically the only operation in the use of logarithms that requires any appreciable amount of time. The other operations are all simple, as will be shown in an early article explaining how the engineer can make practical use of this convenient mathematical tool in the multiplication and division of long numbers and in raising numbers to fractional powers.

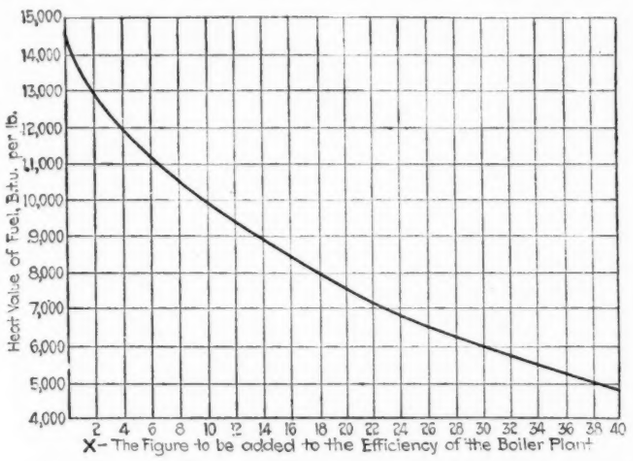
Comments on A. S. M. E. Revised Code for Testing Stationary Boilers

Some Criticisms and Suggestions for Further Revision, and the Necessity of an International Code

By DAVID BROWNLIE

I HAVE studied with much interest the Revised Boiler-Test Code of the American Society of Mechanical Engineers, and while admitting that it is, in its present form, undoubtedly much superior to the prevailing (1913) British Code of the Institution of Civil Engineers, and also to what I may term the "Continental" Code of the German Society of Engineers (in vogue in Germany, Austria, Scandinavia, Norway and Belgium), I am of the opinion that it is still open to much further improvement.

I have been engaged in testing boiler plants for many years, and as a result of the experience of nearly 500 different boiler-plant tests, I have devised a code which I suggest in my new book "Boiler Plant Testing,"[1] should be the



STANDARD CURVE OF EFFICIENCY CORRECTION FOR THE DIMINISHING HEAT VALUE OF THE FUEL

basis of an international code. The general fault with existing codes seems to be that they are far too academic and not adapted to practical conditions, and although the present American Revised Code is very much the best in this respect, it has, I think, still some way to go. Also, for an international code a number of alterations would be necessary because of the different conditions in various countries. It is of course impossible in an article of any reasonable length to consider every point, so that I will confine myself to a few of the more important, taking in all cases, for simplicity, the fuel used to be coal.

Duration of the Test

With regard to the duration of the test, the Revised Code suggests 24 hours, and certainly not less than 10 hours, being more emphatic in the direction of a longer test than the original code. It is very refreshing that the Revised Code realizes to this extent that boiler-plant testing is a practical proposition, and therefore allowances must be made for changes of firemen, light running and periods of banked fires. I suggest, however, that the Revised Code still does not go far enough in this direction, and a much better arrangement would be a test for the usual daily run of the plant at ordinary load, combined with one inclusive week's run (168 hours), taking the essential figures of water evaporated, weight of coal burned, analysis of coal each day (based on hourly samples), auxiliary steam, and flue-gas analysis by means of CO_2 recorders, together of course with any other readings that may be thought necessary under the particular circumstances. The minimum period suggested in the Revised Code for the test, 10 hours, cannot very well be applied to an International Code because, in Great Britain for example, the average working day is 8 hours. It would appear, therefore, to be the best plan to carry out the shorter and very detailed test for the full working hours of the plant, whatever they are, with the proviso, however, that no test of less than 6 hours (with ordinary coal) can be regarded as official. Of course in the case of certain industries, such as paper-making and flour-milling, in which the full load is on continuously day and night, as long a test as possible, 12 to 24 hours, is desirable. It seems to me, however, that the real all-the-year-round performance of the plant, including light running, banked periods and shutdowns at the week-end, would be much more accurately determined by one inclusive week's trial than by the 24 hours' trial suggested by the Revised Code. Certainly, this has been my experience in nearly 400 boiler tests which included such a week's trial.

Analysis of the Fuel

There is still much confusion on the extremely knotty point of the methods to be adopted in expressing the heating value of the fuel, and I must confess I am not very clear what the Revised Code exactly does recommend, although, since the ultimate chemical analysis is regarded as necessary, some form of lower or net heating value is apparently taken.

Considering for a moment the simple essentials of the problem, it is obvious that the heating value of a coal determined, as fired, in an oxygen bomb calorimeter, is a higher or gross value as compared with that in an actual boiler furnace, which is a real net or lower value. This coal contains natural moisture, and in the bomb calorimeter this moisture is first volatilized to steam during the combustion, and is then condensed again inside the bomb to water. Also coal contains hydrogen (say 3½ to 5 per cent in the ash- and water-free sample), which burns to nine times its weight of water in the bomb. This, as before, is volatilized and condensed again. The point is that these two amounts of water remain in the bomb and the latent heat of their volatilization to steam is returned to the calorimeter and recorded as heat value in the coal. Under practical conditions of course this water, which may be as much as 50 per cent of the weight of the coal burned, is not condensed to a liquid again, but passes out of the boiler fires as steam at the temperature of the flue gases, so that the gross value in the calorimeter is higher than the real net value in the furnace. Thus, a given coal of 11,500 B.t.u. gross or higher heating value, with 5 per cent water and 4 per cent hydrogen (as fired) has a real net heating value of only 11,016 B.t.u., taking the temperature of the final exit gases of the plant as 350 deg. F. With regard to the calculations, however, the matter is very complicated. We have in the first place presumably to take an arbitrary figure of 212 deg. F. as the temperature of the exit gases, because this is theoretically the lowest possible figure (to prevent condensation of all the water in the flues), so that we can give the heating value of all fuels irrespective of the plants on which they are burned, and also to avoid the absurdity of giving the advantage of a lower heat value to the coal in the case of a plant with a high and inefficient flue-gas exit temperature.

It may be stated further that all the latent heat in the vaporized water may not finally escape from the plant and be lost, because some of the steam in the flue gases is condensed on exposed portions of the plant. As there is added

[1] Published March, 1922, by Messrs. Chapman & Hall, Ltd., London, and E. P. Dutton & Co., Inc., New York City.

to these inaccuracies the complication of the determination of the percentage of hydrogen in the coal, to arrive at a rather arbitrary net heating value, I have suggested that the net heating value basis be abandoned entirely, and that the coal be first dried, the gross heating value of the dried sample determined, and the figure then calculated back to the "as fired" sample. Another suggestion, however, that might be applicable is to calculate the percentage of hydrogen always as 0.03 per cent of the heating value of the dried coal, which in most cases would give a figure very near the net heating value with flue gases at 212 deg. F. In any case of course, the chief point is to arrive at some definite agreed figure, as the term "heating value of coal" as used today is most confusing.

Moisture in the Steam

The Revised Code states, as before, that the percentage of moisture in the steam must be determined in each case and deducted from the gross evaporation of the boilers, following on the elaborate instructions as to the methods of sampling the steam and the use of the throttling calorimeter given in the original code. From a theoretical point of view the percentage of moisture in the steam, which may vary from practically zero to as much as 5 per cent, should of course be deducted from the evaporation, but a long and painful experience of the use of steam calorimeters leads me to doubt whether the figures obtained are worth the trouble. There is in the first place no really accurate method of taking a true average sample of steam issuing from a boiler, especially in view of the fact that when the moisture exceeds 2 per cent the water tends to creep along the inside of the pipe, and presumably the velocity of the steam in the center of the pipe is often greater than at the sides. Again there is always an unknown amount of inaccuracy due to condensation. Thus if the sample is taken directly from the vertical branch pipe a few inches above the top of the boiler, "showers" of condensed steam are likely to occur, whereas if the sample is taken past the main steam valve there is inaccuracy due to condensation of the steam in the pipe because of radiation, thus giving a higher percentage of moisture than is actually present in the steam leaving the boiler. Again condensation errors occur in the calorimeters themselves, which in any case do not give very accurate results when the moisture content in the steam is high, so that for example, the British Institute of Civil Engineers' Code is reduced to recommending the installation of steam driers in the steam-pipe circuits (the modern drier inside the boiler being little know in 1913 when this Code was revised) so as to reduce the moisture content to less than 2 per cent, and then determining this with a calorimeter. I suggest, therefore, that on present knowledge the determination of the percentage of moisture in the steam is not worth the time and trouble involved.

Auxiliary Steam or Power

The most serious defect, however, that still remains in the Revised Code is undoubtedly the scanty attention given to the vital question of the amount of steam or power used auxiliary to the production of steam. If a given boiler plant is taking 10 per cent of the steam production in the way of boiler-feed pump, mechanical draft, economizer scrapers, mechanical stokers with coal and ash conveyors, and so on, then this must be deducted in calculating the real net working efficiency of the boiler plant. That is to say, if the boiler is evaporating 50,000 lb. of water to steam per hour and 5,000 lb. is being used for auxiliaries, then the real net evaporation, from which the net efficiency must be calculated, is 45,000 lb. per hour, not 50,000 lb., since only 45,000 lb. is available for useful work in the factory. It is true that in the original Code there is some mention made of a "correction for steam or power used for aiding combustion," but there is no indication given at all that a boiler test carried out without determining all the different amounts of auxiliary steam or power used and deducting these in calculating the net working efficiency is just as defective and of as little real practical value as would be a test without the amount of coal or water used, or a determination of the heating value of the coal. It is not to be wondered at, therefore, that very few steam users realize the extent to which their coal bill is increased by the consumption of various boiler-plant auxiliaries, the average figures of which for cylindrical-fire-tube-boiler plants in good condition are as shown in Table I.

TABLE I—AVERAGE STEAM CONSUMPTION OF AUXILIARIES WITH FIRE-TUBE BOILERS

Appliance	Percentage Used of the Steam Production of the Plant
1. Coal conveyor	0.50
2. Ash conveyor	0.25
3. Mechanical stoker mechanism (or moving hand-fired furnace)	0.60
4. Steam jets	6.00
5. Mechanical draft	2.75
6. Boiler-feed pump	1.00
7. Water-softening plant (pump)	0.50
8. Economizer scrapers	0.15
9. Electrolytic anti-corrosion process	0.50
10. Soot cleaners, etc.	?
Total	12.25

For water-tube-boiler plants the corresponding figures are shown in Table II.

TABLE II—AVERAGE STEAM CONSUMPTION OF AUXILIARIES WITH WATER-TUBE BOILERS

Appliance	Percentage Used of the Steam Production of the Plant
1. Coal conveyor	0.50
2. Ash conveyor	0.25
3. Mechanical stoker mechanism (or moving hand-fired furnace)	0.50
4. Steam jets	nil
5. Mechanical draft	1.50
6. Boiler-feed pump	1.00
7. Water-softening plant (pump)	0.50
8. Economizer scrapers	0.10
9. Electrolytic anti-corrosion process	0.50
10. Soot cleaners, etc.	?
Total	4.85

These figures are based on the usual methods in vogue of using small non-condensing steam engines or electric motors, and of course individual plants are very much worse. Thus I have tested over 130 cylindrical-fire-tube-boiler plants using steam nozzles, and found that while the average steam consumption of these nozzles was 6½ per cent of the production, individual plants varied from 0.5 per cent to no less than 21½ per cent of the production.

The point is, however, that even a comparatively up-to-date water-tube-boiler plant may easily be using 5 per cent of the coal bill, or a cylindrical-boiler plant 10-12 per cent, simply for auxiliary steam plant without doing any useful work at all from the plant-efficiency point of view, and for any International Code it must be regarded as essential to deduct this amount of steam in calculating the net working efficiency of a boiler plant.

Flue-Gas Analysis

I think the methods suggested in the Revised Code are still much out-of-date and far too academic. For example, little or no mention is made of automatic gas-analyzing machines, and practically all the methods suggested relate to slow and antiquated hand modes of analysis, most of the space in the original Code being devoted to the "Orsat" and the "Hempel" apparatus. In practice these appliances are of little or no use for a regular series of analyses, and are only of value in analyzing at the end of a considerable number of hours a large gas sample taken continuously by an automatic sampling apparatus, a valuable aid to boiler testing which does not seem to be mentioned at all by the Code. The sentence "Instruments known as CO_2 recorders are useful if their accuracy is established" simply shows that the majority of the engineers who have drawn up the Revised Code can have had little or no practical experience with CO_2 recorders. One might as well say that temperature-recording instruments or coal-weighing machines of all kinds are useful if their accuracy is established, and the hazy idea that CO_2 recorders are usually inaccurate is at least ten years out of date.

I would suggest that the use of automatic flue-gas-analyzing machines giving at least 12 to 15 analyses per hour, be compulsory, so that a boiler test would give well over 100 determinations of CO_2 per day instead of about a dozen as with the ordinary hand apparatus. Also the code com-

mittee evidently does not realize the importance of the determination of the percentage of CO and other unburnt gases, which ought to be made compulsory. This can be done by taking a very large sample of the flue gases continuously over a number of hours, and analyzing the mixed gases by hand, or better still, by using some modern type of machine which analyses automatically both CO_2 and CO.

The Efficiency Calculation Based on the Heat of the Fuel

The Revised Code, like every other code, simply bases the efficiency on the actual heat value of the fuel used, irrespective of price or quality; that is to say, there is no relation shown between mere academic efficiency and the cheap production of steam, which seems to me to be a very serious omission.

After all, the real object of boiler-plant testing is to save money, to produce steam as economically and cheaply as possible, and yet the Revised Code ignores this essential point.

I have suggested the use of a new curve, shown in the figure, to be known as the "Standard Curve of Efficiency Correction for the Diminishing Heat Value of the Fuel," whereby a value X is added to the ordinary calculated efficiencies so as to bring every plant more or less in line in this respect. Thus, for example, with a coal of 7,000 B. t. u. and a calculated efficiency of 59 per cent, the value of X is 23, which would make the corrected figure 82 per cent, whereas with coal at 14,000 B.t.u. X is 0.5 per cent, giving a corrected figure of 72½ per cent efficiency, for an actual efficiency of 72 per cent. This would then show the second plant, burning refuse coal and giving inferior results according to the Revised Code, to be really much better, as of course it is in practice.

There are many other points that could be dealt with if space permitted, which I have considered in detail in my book.

I would suggest, however, the use of the additional figure "lb. water from and at 212 deg. F. per 1,000,000 B.t.u.," since "lb. of water from and at 212 deg. F." is rather a meaningless figure in view of the fact that the fuel used might be anything from 6,000 to 15,000 B.t.u. per lb. Moreover, the reading of the barometer seems to me to be a waste of time. I would suggest also much simpler methods of calculating and expressing the results, and the abolition of the usual "heat-balance sheet" figures because of the number of quite arbitrary assumptions that are necessary to give a "balance."

Would Abolish the Heat Balance

The essentials of the matter are not a balance sheet at all, but the percentage of heat of the original coal that passes into the boiler, the superheater and the economizer and the net total of heat that passes out of the combined boiler plant in useful steam to the factory after deducting the auxiliary steam or equivalent. I think the committee is quite right in refusing to separate furnace efficiency and boiler efficiency, and the latter would be a meaningless complication.

There ought also, in my opinion, to be some method of determining the amount of grit and solid matter in the chimney gases, a particularly important point in view of the modern short steel chimneys and mechanical draft, and also of allowing for labor, attendance, repairs, upkeep, interest and depreciation. Thus, for example, according to the present Revised Code, a boiler plant working at a much reduced output, on say, 75 per cent net working efficiency, but with consequent greatly increased labor, attendance, interest, depreciation and other costs, would be regarded as doing better than another plant at, say, 72½ per cent with a proper evaporation per boiler, whereas in reality this plant is producing the steam much cheaper because of less labor, attendance, interest, and the other costs as given. That is to say, the Revised Code has also in this way the inherent defect of no relation between efficiency and cheap steam production.

[*Mr. Brownlie's comments on the Revised Code and upon boiler testing in general are discussed editorially on page 566 of this issue.*—Editor.]

Deterioration of Coal in Storage

The loss by deterioration of coal at ordinary temperatures is small when compared with that caused by rapid oxidation at elevated temperatures and the loss by spontaneous ignition. To overcome the hazards of self-heating and spontaneous combustion, various means of storage have been suggested, such as storing under water or in an atmosphere of carbon dioxide; screening the coal and storing only large sizes; cooling the coal pile by means of ventilating pipes; covering the coal pile with sand or with a layer of fine coal to prevent breathing of the heap, and so forth. Many of these methods, according to the United States Bureau of Mines, do more harm than good, and others are prohibitive on account of their cost.

The tendency of coals to fire spontaneously differs with their age, the younger coals being the most dangerous. No case has been recorded in which anthracite fired spontaneously, even fines and slack storing safely. At the other extreme is lignite, which cannot be stored, even in lumps, with safety, except under water. Between these two extremes are the various grades of bituminous coals, the class that is most commonly stored. The liability of different bituminous coals to fire varies widely on account of differences in the coal; but, broadly speaking, the bituminous coals of the eastern part of the United States store better than those of the Middle West. These, in turn, are safer to store than the sub-bituminous coals of the Intermountain region.

While the tendency to fire will vary widely in any one class of coal, generally speaking, the higher the rank the less the danger of fire and the less the deterioration in storage. The classification as to self-heating coincides with the classification of coals, beginning with lignite as the most dangerous, ranging through sub-bituminous, bituminous, semi-bituminous, and anthracite as the least prone to spontaneous combustion. The presence of fines in a coal pile should be avoided. Coal should be handled as little as possible and should be screened wherever practicable before storing.

Experiments show that with the same coal, moist air will give a lower "critical," or spontaneous-combustion temperature, than dry air. Therefore, wetting the pile to retard heating is not good practice unless the coal is completely immersed.

Instead of hastening spontaneous combustion, partly oxidized coal seems to act as a deterrent when mixed with fresh coal. It appears that the danger in mixing two grades, or in storing coal on the same pile at different times, arises from physical rather than chemical causes. If no heating has occurred at the surface of the heap, it is safe to pile more coal on top, provided there is no accumulation of fines at the contact of the new and old coal. A mixture of two kinds of coal will heat more rapidly than the poorer of the two.

On account of the low conductivity of coal, cooling by artificial ventilation is almost impossible unless the air reaches every part of the pile. Generally, the air travels through the stack in currents and exerts no cooling effects on parts a short distance away from its channels. Exclusion of air as much as possible, in order to stop oxidation, is more successful than attempts at ventilation to dissipate the heat generated.

Coals, under various physical and chemical conditions, have been tested to determine the temperature at which they generate heat so rapidly that, provided no deterrent is applied, they will eventually ignite. This temperature has been arbitrarily called the "critical temperature." Under similar conditions of heating and aërating, this critical temperature is an index of the liability of a coal to fire spontaneously. The "critical temperature" method of testing may be applied to the various coals of the country for grading their relative tendencies to fire spontaneously, and the Bureau of Mines expects to develop this method further and apply it in a survey of the coals of the United States.

The results of these tests are summarized in Bulletin 3, Coal-Mining Investigations series, which is distributed by the Carnegie Institute of Technology, Pittsburgh, Pa., at a price of 25 cents.

News in the Field of Power

New York Hydro-Electric Power Bill Discussed

A public hearing was held at Albany on April 4 on the Rabenold water power bill, representing the administration policy and carrying out Democratic platform pledges in New York State.

The attack on the measure was lead by Henry W. Killeen, of Buffalo, representing the Lower Niagara Power & Supply Co., who charged that the "measure was never written with a view of having it become a law." Mr. Killeen provided the sensation of the hearing by declaring the bill had apparently been written as a gesture.

William Barclay Parsons, of New York, said the measure would kill private enterprise and that the municipalities would be compelled to take over the distribution of power under the bill. "The measure defeats itself," he asserted, "by making no provision for the sale of power to electric railways in spite of the demand for cheaper transportation."

Figures tending to show that governmental development of hydro-electric power in Canada was not found to produce cheaper power, as claimed by proponents of the bill, were submitted by Frederick C. Corey, of the Lockport, Niagara Power Company.

Defense of the measure was undertaken by Charles E. Van Kennen, special deputy attorney-general in charge of the Governor's plan, who asserted that the measure affected only the St. Lawrence and Niagara Rivers and was intended to prevent a private monopoly of electricity "similar to the coal monopoly in Pennsylvania."

Former Mayor Cornelius F. Burns of Troy, appearing for the Mayors' Conference, spoke in favor of the bill, declaring it to be a "result of the arrogance of the power interests." John M. O'Hanlon, representing the State Federation of Labor, was recorded in favor of the bill.

Another note regarded as significant was sounded by E. J. Clapp, representing William Randolph Hearst, who criticized the failure of the state to have anyone present capable of discussing the question as raised by the power interests.

Opposition has developed to the measure in considerable strength from the small up-state cities and villages, which are now adequately served by local power companies organized for the most part on a community-owned basis. The great objection raised against the measure is its almost mandatory provisions and the fact that, without a certificate of convenience and necessity, a group of office holders in physical control of the machinery of government have it within their power to bankrupt a going corporation in which the majority of the business interests of a community have an equal investment. The measure with some minor amendments is scheduled to pass the Senate at an early date.

F. M. Feiker Will Conduct Survey of Raw Materials

At the request of Secretary Hoover, of the Department of Commerce, F. M. Feiker, Assistant to the President of the McGraw-Hill Co., Inc., has again been granted leave of absence to undertake the organization and general direction of the world survey of raw materials, supplies, rubber, sisal hemp and nitrates, for which Congress recently made an emergency appropriation of $500,000.

Mr. Feiker served as Assistant to the Secretary of Commerce during the first year of Mr. Hoover's administration as general assistant in organizing the personnel and industrial trade contact committees in relation to the Bureau of Census, the Bureau of Standards and the Bureau of Foreign and Domestic Commerce.

Westinghouse Electric Co. Designs New Turbine

The Westinghouse Electric & Manufacturing Co. is now doing research and design work in its South Philadelphia plant on steam turbines to operate at a pressure of from 1,000 to 1,200 lb. per sq.in. This is a further attempt to utilize high temperatures and high pressures in turbine operation. The highest pressure now being considered for practical application is that to be used in the Crawford Avenue station of the Commonwealth Edison Co., where a pressure of 550 lb. and a temperature of 750 deg. F. will be used.

Turbine Wreck at Indianapolis

A 12,500-kw. turbo generator was completely wrecked at the Mill Street station of the Indianapolis Light and Heat Co., about 5 a.m. of April 2. Two men were injured and considerable damage was done to the plant. However, through the co-operation of some of the larger customers in curtailing their demand and with the Kentucky Avenue plant helping out, service was partly restored. An investigation is now being made into the cause of the wreck and it is hoped to publish the details later.

Caribou Power Plant To Install New Equipment

The present rate of growth in increased load demands is the reason given by J. B. Black, general manager of the Great Western Power Co., of California, for the immediate installation of a third unit of 22,000 kw. capacity in the Caribou plant on the North Fork of the Feather River. This will entail the expenditure of approximately $1,500,000. Surveying parties are already in the field and bids for hydraulic and electrical equipment will be called for within the month. The installation will include penstock, turbine, generator. exciter, transformers and other electrical equipment.

Seeks to Safeguard Water Supplies

Senator Rabenold has introduced in the New York State Legislature a measure to amend the conservation law of 1911 by adding a new section No. 526. as follows:

The powers, duties and jurisdiction of the water control commission with respect to new and additional sources of water supply for municipal corporations shall extend to and include all waters, and sources of water wherever located, notwithstanding the provisions of any other law, general or local, restricting or denying the right to acquire lands, easements and water rights in particular localities, and no other body, board, commission or authority shall be empowered to determine any of the matters embraced in section 526 of this act. All acts or parts of acts inconsistent with this act, in so far as they are inconsistent, are hereby repealed. This act shall take place immediately.

Canada May Import Welsh Coal

Canada purchased 874,000 tons of British coal last year instead of the nominal amount of 1,000 tons imported during 1921. On account of the American coal strike the industrial corporations and municipalities in Ontario and Quebec were obliged to go to Welsh and North England collieries for anthracite.

Representatives of several Welsh exporting firms have visited Canada recently to ascertain whether colliery owners in Wales can build up a permanent trade in this much-needed article with this British Dominion. It is possible to ship from April to November, as the ice breaks up on lakes and rivers in April and sets in again in November. This coincides with the period when the price of anthracite is lowest and when European demands are lightest.

New York State Department of Education Offers Scholarships

The State of New York is offering 25 industrial teachers' scholarships of $1,000 each to qualified trade and technically trained men. Persons receiving these scholarships will spend one year at the Buffalo State Normal School preparing to teach their subjects in the public vocational schools of the state. Salaries now paid vocational teachers range from $1,800 to $3,500 after a period of experience.

Applicants for scholarships must be over 21 years and under 36 to qualify. They must be residents of the State of New York and citizens of the United States. Five years of all around experience of journeyman grade will be necessary to qualify in one of the following trade, industrial or technical occupations: automobile repairing; machine-shop work; electrical constructing, repairing and operating; machine drafting and designing; electrical drafting and design; architectural drafting and designing; bricklaying; sheet-metal working; painting and decorating; carpentry; printing, including composition, presswork and bookbinding; mens' tailoring and garment design.

Applications for scholarships are not received after June 1, 1923.

Patent Office Looking for Young College Men

Positions as assistant examiners for the United States Patent Office, at Washington, D. C., are being advertised by the Civil Service Commission. Graduates of technical schools and those about to graduate are advised that they will find the Patent Office work in examining applications for patents interesting and diversified as the field covers practically every art and science known. The positions offered are permanent and are not affected by industrial depressions. The initial salary is $1,740 per annum and the maximum, $4,000, will be raised to $5,000 on July 1, 1924 by a law recently passed.

An examination was held on April 4-6, 1923, and others will be held in May and June. It is suggested that books describing manufacturing processes and industrial chemistry be read in connection with the subject of technics so that the applicant will be prepared to answer questions as to how commercial things are made and how they work. For further information address the Civil Service Commission, Washington, D. C.

The Potomac Electric Co. Installs New Equipment

The Potomac Electric Power Co., of Washington, D. C., is to install three 13,000-sq.ft. boilers as an addition to its Benning plant. Stone & Webster, in charge of the improvements, have already invited bids, which are to be opened in the near future.

The company will also install a 20,000-kw. 60-cycle 13,000 generating unit. Work on additions and installations will begin this summer, and it is expected that these will be available by the fall of 1924. This addition will bring up the total generating capacity to 118,000 kw. It is expected that with these additions the company will have sufficient boiler capacity for the next three years even if the building operations in the District of Columbia continue at the high rate of the last two years.

Individual Blowers To be Used on the "Mayflower"

New oil-burning boilers are being installed in the presidential yacht "Mayflower," replacing the coal burners which heretofore have been in use. The old reciprocating engines will be retained. The individual blowers, being installed, will be the first of the type designed last year by the Navy Department to be placed in actual operation on a government vessel. Standard burners, slightly modified to permit underneath blowers, are used. In substituting oil for coal as a fuel, cleanliness and some economy of operation will be effected.

New Publications

5,000 Plain Answers to Direct Questions on Steam, Hot Water, Vapor and Vacuum Heating. Second edition—revised and enlarged. By Alfred G. King. Published by the Norman W. Henley Publishing Co., 2 West 45th St., New York City, 1923. Cloth; 6 x 9 in.; 253 pages; 157 illustrations and 28 tables. Price, $2.50.

As an intensely practical, easily understood and up-to-date book on heating, this volume should be in the library of the operating engineer whose work involves the operation of any type of heating system. Such work ordinarily includes not only the actual operation of a system already installed, but the occasional installation of additional equipment and the rearrangement of existing equipment to meet the needs of a growing plant. The last few years have witnessed a marked advance in the technique of heating, and the engineer must be thoroughly familiar with the latest practice if he is to do full justice to his job.

Good as is the information contained, the method of presentation will appeal quite as much to the busy practical man. Starting with the elements, the book proceeds with a series of simple and well chosen questions such as a man looking for useful knowledge would ask of an expert who was willing to give him a day or two of his time. The answers are equally simple and direct. They "get across."

The following list of chapter titles gives an idea of the scope of the book: Theory and Laws of Heat; Methods of Heating; Chimneys and Fuels; Boilers for Heating; Boiler Trimmings and Setting; Radiation; Steam Heating; Boiler, Radiator and Pipe Connections for Steam Heating; Hot-Water Heating; Two-Pipe Gravity System of Hot-Water Heating; Circuit System of Hot-Water Heating; Overhead System of Hot-Water Heating; Boiler, Radiator and Pipe Connections for Gravity Systems of Hot-Water Heating; Accelerated Hot-Water Heating; Tank-in-Basement Systems of Hot-Water Heating; Expansion-Tank Connections; Domestic Hot-Water Heating; Valves and Air Valves; Modern Methods of Heating; Systems of Modified Heating; Heating Greenhouses; Information, Rules and Tables. The tables in the back of the book contain a large amount of valuable information.

Obituary

T. T. Parker, we sincerely regret to announce to the readers of *Power*, died on March 28, in his sixty-sixth year. He was an engineer and inspector and contributed many interesting articles to *Power*. His career began as a fireman of a locomotive boiler. Later he became stationary engineer in charge of a plant at Springfield, Ohio. After this he was employed as salesman by a manufacturer of feed-water heaters and purifiers. In 1893 he entered the service of the Fidelity and Casualty Company of New York, as an inspector, stationed at Chicago. In 1908 he was brought to New York as assistant superintendent of the Inspection Department. This position he held until, because of illness, he was obliged to give up active work. At the time of his death he was living in Chicago.

Mr. Parker was a member of The American Society of Mechanical Engineers; he was a great student of all matters pertaining to the design and operation of steam boilers. He was considered an authority on steam-boiler inspections, and he was an inventor of many devices having to do with the better design and operation of pressure-containing vessels. He was widely known not only among boiler inspectors, but also among boiler manufacturers, whose confidence he always enjoyed. He was unusually well liked by his associates and very highly esteemed by his employers. He was twice married. He had two sons by his first wife, and is survived by his second wife, two sons and an adopted daughter.

Personal Mention

Col. John Price Jackson was elected "executive director," at a salary of $15,000, of the Sesqui-Centennial Exhibition which is to be held in Philadelphia, in 1926.

Prof. L. P. Breckenridge, chairman of the department of mechanical engineering, Sheffield Scientific School, Yale University, will retire in June after fourteen years of active teaching in that institution. He is an active member of the A.S.M.E. and served as vice-president from 1907 to 1909.

Society Affairs

The **St. Louis, Mo., Section of the A.S.M.E.** will hear Dean Dexter S. Kimball of Cornell University speak on April 30, 1923. This will also be ladies' night and a dance will follow the address.

The Executive Board of the American Engineering Council, F.A.E.S., has decided to undertake a nation-wide coal-storage investigation. The object of the survey is "to determine the facts relating to the engineering, chemical and economic factors involved in, and their influence upon, coal storage at the mine and by large and other consumers of coal." This study to be of the greatest benefit should be finished by Nov. 1, 1923, was the decision reached by the Board at their recent meeting in Cincinnati, Mar. 23-24.

The A. S. M. E. has recently appointed a Standing Committee on Professional Conduct. It is authorized to interpret and enforce the new Code of Ethics of the society, to which every member is now required to subscribe. It will handle all inquiries in regard to professional conduct and will also take up any larger cases of ethics in which the standing of the engineering profession is involved. Past-Presidents Charles T. Main and Fred J. Miller, Past Vice-President Edward N. Trump, Past Manager Charles L. Newcomb and George I. Rockwood has accepted service on this committee. It is believed that the new committee is sufficiently professional to warrant the belief that the opinions of this committee will be as unbiased as can be obtained.

The **A.S.M.E.** at their Spring Meeting will have on their program the following papers: "The Development of Hydro-Electric Power Plants in Ontario," by Fred A. Canby; "Power Development in the Province of Quebec," by Julian C. Smith; "Management Engineering as Applied to the Pulp and Paper Industry," by R. B. Wolf; "A Practical Laboratory and Drawing Room Course in Industrial Engineering," by M. A. Lee; "Construction of Steel-Frame Box Cars by the Jig Method," by H. Naylor; "Design, Construction and Operation of Gasoline Motor Cars for Use in Railway Service," by C. E. Brooks; "Mechanical Features of Hydro-Electric Plants with Special Reference to the Chippawa Development," by N. G. Acres; "Sectionalization and Remote Control of High-Pressure Steam Lines," by Peter Payne Dean; "Port Development," by Mr. McElwee; "Harbors of Montreal," by Mr. Cowie; "Bleachery Engineering and Operation," by S. P. Bascom & J. C. McDowell; "Endurance Test Data and Their Interpretation," by K. Heindlhofer and H. Sjovall; "Bending of Curved Tubes of Rectangular Cross-Section," by S. Timoshenko; "Control of Civil Flying"; "Chimney Design," by A. Cotton; "Lignite Char," by O. P. Hood.

Business Notes

The Chicago Fuse Manufacturing Co. announces the retirement of Arthur D. Dana, of New York City from the active duties as president of the company, to become chairman of the Board of Directors. William W. Merrill becomes president, George C. Reid, vice-president and treasurer, Walter D. Dana, vice-president, F. Trautman, secretary, E. J. Hamilton, manager of sales.

Coming Meetings

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, April 16-18; Spring meeting at Montreal, Canada, May 28-31.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, April 18-20.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Spring meeting at Pittsburgh, Pa., April 24-26.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Association of Engineers; C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

National Association of Manufacturers; George S. Boudinot, 50 Church St., New York City. Annual conference, New York City, May 14-16.

International Railway Fuel Association; J. G. Crawford, 702 East 51st St., Chicago. Annual meeting at Cleveland, Ohio, May 21-24.

American Water Works Association, 163 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

American Boiler Manufacturers Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

American Order of Steam Engineers; W. J. Brice, 1428 Callowhill St., Philadelphia, Pa. Annual convention at Philadelphia, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th annual convention at Toronto, Canada, June 25-28.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ohio, June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., July 12-14; James F. Morgan, 53 Devonshire St., Boston, Mass.

Trade Catalogs

Condensers, Surface—Ingersoll-Rand Co., 11 Broadway, New York City. Form 9035. Illustrates and explains their large unit type of surface condensers.

Recording Gages for Pressure and Vacuum, Bristol Company, Waterbury, Conn. Catalog No. 1006 contains 84 pages of text and illustrations. Beside the different types of instruments shown, there is a variety of charts listed which adapt the gages to practically every application where pressure of liquids, gases, steam or air are required to be measured.

Synchronous Motor Drive for Ammonia Compressors; General Electrical Co., Schenectady, N. Y., Bulletin No. 41316 contains information with regard to the application of synchronous motors to ammonia compressors; starting torque; conversion from steam to electric drive; flywheels; motor and compressor data; belted equipment and rope, chain and gear drive.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Mar. 26, 1923	Apr. 2 1923
Pool 1,	New York	$4.00–4.50	$4.00–4.25
Smokeless,	Columbus	4.25–4.75	4.00–4.50
Clearfield,	Boston	2.25–3.00	2.40–3.75
Somerset,	Boston	2.75–3.50	3.25–3.75
Kanawha,	Columbus	2.50–3.00	2.50–3.00
Hocking,	Columbus	2.35–2.60	2.25–2.50
Pittsburgh No. 8	Cleveland	2.25–2.50	2.15–2.35
Franklin, Ill.,	Chicago	3.00–3.25	3.00–3.25
Central, Ill.,	Chicago	2.50–2.75	2.50–2.75
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	1.85–2.25	1.75–2.00
S. E. Ky,	Louisville	2.50–3.25	2.50–3.25
Big Seam,	Birmingham	2.00–2.25	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—April 5, Port Arthur light oil, 22@25 deg. Baumé, 5⅜c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—March 24, 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $2.39 per bbl. in tank cars.

Philadelphia—April 2, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3), 3⅛@3⅜c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

St. Louis—April 2, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.20 per bbl.; 32@36 deg., gas oil, 5½c. per gal.; 36@40 deg., distillate, 6c. per gal.

Pittsburgh—March 27, f.o.b. local refinery, 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.; 34 deg., neutral, 9⅜c. per gal.

Dallas—March 31, f.o.b. local refinery, 26@30 deg., $1.60 per bbl.

New Plant Construction

PROPOSED WORK

Ala., Florence — The U. S. Engineers Office will receive bids until Apr. 27 for furnishing and installing steam boilers, etc., on the United States towboat, General John Coffee.

Calif., Los Angeles—J. M. Bowen, et al., c/o G. A. Lansburg, Junior Orpheum Bldg., are having preliminary plans prepared for the construction of a theatre building on Highland Ave. Cost will exceed $500,000.

Calif., San Francisco—M. I. Schwartz, Archt., Nevada Bank Bldg., is receiving bids for the construction of a 9 story, 56 x 137 ft. hospital building on Sutter St. near Larkin St., for A. Abrams, 2151 Sacramento St. Estimated cost $500,000. Equipment detail not reported. Noted Mar. 27.

California—H. L. Shannon, Engr., 2730 Sacramento St., San Francisco, is preparing preliminary plans for power development, including the construction of a small diversion dam, water to be carried through flume and ditch about 10 mi. long to power house developing 10,200 hp., in Tehama County. Estimated cost $600,000. Owner's name withheld.

Calif., Santa Barbara—St. Vincent's Orphanage is having plans prepared for the construction of an orphanage building, including separate power house and laundry Cost will exceed $250,000. Soule, Murphy & Hastings, 1206 State St., Santa Barbara, Archts. Equipment detail not reported.

Calif., Monterey—R. Jacks, c/o O'Brien Bros., Inc., Archts., 315 Montgomery St., San Francisco, is having plans prepared for the construction of a 2 story hotel, here. Estimated cost $350,000. Equipment detail not reported.

Conn., Meriden—The city, School Dept. plans to build a 3 story Junior High School. Estimated cost $750,000. Engineer or architect not selected.

Conn., New Haven—The Bd. Educ. will receive bids until Apr. 20 for the construction of a 3 story, 200 x 200 ft. junior high school, to be known as the Augusta Lewis Troup School, on Edgewood Ave. Estimated cost $700,000. C. S. Palmer, 114 Whitney Ave., New Haven, Archts. Vocational equipment will be installed. Noted July 18.

D. C., Washington—The Potomac Electric Power Co., 231 14th St., N. W., is having plans prepared for extension to power plant at Benning, consisting of addition to turbine house, boiler house and electrical galleries; 20,000 kw. turbo generator, 60 cycle, 13,200 volt, with condenser and auxiliaries; 1,400 hp. boilers, stacks, etc., necessary bus structure, oil circuit breakers, exciters, etc. Estimated cost $1,800,000. Stone & Webster, Inc., 147 Milk St., Boston, Mass., Engrs.

D. C., Wash.—J. A. Wetmore, Acting Supervising Archt., Treas. Dept., will receive bids until Apr. 25 for the construction of additions, including quarters for ambulant patients; semi-ambulant patients, male attendants, female attendants, nurses and aids, residences for officers and administrative assistants; boiler house and smoke stack; roads and approaches, for the United States Veterans' Hospital at Chelsea, N. Y.

Fla., Ormond Beach—J. P. Vining is having plans prepared for the construction of a 2 story hotel, 150 ft. long, on the site of the Bretton Inn. Estimated cost $250,000. Magaziner-Eberhard-Harris, 603 Chestnut St., Phila., Pa., Archts. Equipment detail not reported.

Ill., Chicago—The A. B. C. Auto Radiator Wks., 920 West 69th St., in the market for one automatic air compressor.

Ill., Chicago—J. Horwitz, 10 South La Salle St., is having plans prepared for the construction of a 2 story, 244 x 307 ft. theatre, stores and office building, including steam heating system, on Robey and Belle Plaine Sts. Estimated cost $750,000. Denson & Oman, 5 North La Salle St., Archts.

Ill., Chicago — C. W. and G. L. Rapp, Archts., 190 North State St., are preparing plans for the construction of a 6 story, 100 x 142 ft. stores and office building, including steam heating system, on Rush and Ohio Sts. Estimated cost $500,000. Owner's name withheld.

Ill., Springfield—The city, R. G. Moore, City Clk., office of the Mayor, will receive bids until Apr. 23 for furnishing tools, labor, materials and equipment for improvements to city pumping station, including (1) furnishing and erecting one complete 10,000,000 g.p.d. steam turbine driven centrifugal pump; (2) furnishing f.o.b. cars, Springfield, two 3,500 g.p.m. motor driven low service centrifugal pumps; (3) furnishing all labor and material and constructing complete settling basins. Burns & McDonnell Eng. Co., 402 Interstate Bldg., Kansas City, Mo.

Ind., Marion—The Indiana General Service Co. is in the market for coal handling machinery and equipment for $350,000 coal storage plant in connection with its lighting plant.

Ia., Waterloo—The Rath Packing Co. is having plans prepared for the construction of a 5 story, 90 x 100 ft. cold storage and refrigerating plant. Estimated cost $150,000. Henschien & McLaren, Old Colony Bldg., Chicago, Archts.

Kan., Atwood — The city will hold an election this month to vote on a $30,000 bond issue for the construction of a reservoir and pumping station.

Kan., Independence—The City Clerk will receive bids until May 3 for furnishing pumping equipment for a sewage disposal plant, including one 1,550 g.p.m. centrifugal pump driven by a 20 hp. 50 deg. vertical motor, two 775 g.p.m. centrifugal pumps driven by two 10 hp. 40 deg. vertical motors, panels, switches, floats, self starters and all auxiliary equipment. H. W. Crawford, City Engr. Noted Feb. 27.

Kan., Phillipsburg—The Phillipsburg Ice & Cold Storage Co. is having plans prepared for the construction of a 1 story, 50 x 100 ft. ice and cold storage plant. Estimated cost $50,000. Private plans.

Kan., Topeka—The Security Benefit Assn., Security Bldg., is having plans prepared for the construction of a hospital. Estimated cost $250,000. Schmidt, Gardner & Martin, 104 South Michigan Blvd., Chicago, Archts Equipment detail not reported.

Mass., Malden—E. L. Snider, 18 Tremont St., Boston, will build a 5 story, 90 x 200 ft. apartment building on Washington St., here. Cost between $400,000 and $500,000. Equipment detail not reported.

Kan., Wichita—The Co-operative Power Plant, c/o D. S. Jackman, 715 East 13th St., plans to build a central power plant. Estimated cost $150,000. Engineer or architect not selected. The owner is in the market for electric machinery, belting, hangers, pulleys and dynamos.

Ky., Middlesboro—The Kentucky Utilities Co. is in the market for 50 ton electric ice making machinery with auxiliary equipment.

La., Plaquemine—The Mayor and Bd. of Aldermen will receive bids until Apr. 17 for power plant equipment, consisting of two 1,000 gal. motor driven centrifugal fire pumps; two motor driven domestic service pumps; two motor driven air compressors; one 10 panel switchboard; three crude oil engines aggregating 750 hp.; 4,500 ft. 10 in. B. and S. pipe transformers, etc. Estimated cost $150,000. Swanson-McGraw, Inc., United Fruit Bldg., New Orleans, Consult. Engrs.

La., Welsh—The town is having plans prepared for the completion of its waterworks system and the remodeling of its electric light plant. Estimated cost $115,000. Swanson-McGraw, United Fruit Bldg., New Orleans, Consult. Engrs.

La., Youngsville—The Youngsville Sugar Co. is in the market for sugar mill machinery and power house equipment.

Mich., Ann Arbor — York & Sawyer, Archts., 50 East 41st St., New York, will receive bids until Apr. 16 for the construction of a law school for the University of Michigan, here. Estimated cost $2,000,000. Equipment detail not reported.

Mich., Iron Mountain—The Michigan Iron Land & Lumber Co. is having plans prepared for the construction of a 51 x 261 ft., wood distillation plant and a 115 x 145 ft. storage building. A. Kahn, 1000 Marquette Building, Detroit, Archt. Steam heating and power plant will be installed, including 4 boilers and equipment, conveyor system and fuel handling equipment, engines and generators.

Mich., Marquette—Schenck & Williams, Archts., 908 Mutual Home Bldg., Dayton, Ohio, will receive bids until Apr. 16 for the construction of a 7 story, 56 x 125 ft. hotel, here, for the Kawbawgan Hotel Co. Estimated cost $300,000. Equipment detail not reported.

Mich., Zilwaukee—The Consumers Power Co., Jackson, F. Gavagan, 134 South Washington St., Saginaw, Supt., is having plans prepared for the construction of a 110,000 hp. steam plant on the Saginaw river, here. Private plans.

Minn., Owatonna—The city, C. J. Servatins, Clk., is having plans prepared for the construction of improvements to waterworks system, including additional mains, pumps, 500,000 gal. tank on 100 ft. tower, etc. Estimated cost $100,000. J. H. A. Brahtz, 409 Metropolitan Opera House Bldg., St. Paul, Engr.

Minn., Red Lake Falls—The Red River Power Co., Grand Forks, N. Dak., plans improvements to power plant, including repair of dam, here. Estimated cost $15,000. The owner is in the market for waterwheel and generators.

Mo., Hannibal—The Storis Ice & Coal Co., W. Storis, Pres., plans to build an ice plant on Bridge and Ferry Sts. Estimated cost $50,000. Engineer or architect not selected.

Mo., Oran—The city has had a preliminary survey made and will soon vote on bonds for the construction of an electric light plant and distribution system, including oil burning engine, about 3 miles of wire, poles, 35 street lights, also waterworks improvements, including 2½ miles of 4, 6 and 8 in. pipe, 20 hydrants, two pumps, plant building, etc. Estimated cost $70,000. W. A. Fuller, 1917 Railway Exch. Bldg., St. Louis, Engr.

Mo., St. Charles—The Dradenne-Peruque Drainage and Levee Dist. has had plans prepared for levee protection and drainage system for 30,000 acres, including diversion channel, drainage ditches, levees and 40 x 60 ft. pumping station containing pumping equipment, 187,200 g.p.m. capacity and oil engines. Estimated cost $621,233. T. N. Jacob, 1900 Railway Exch. Bldg., St. Louis, Engr.

Mo., St. Louis—The Voll Cooperage Co., Federal Reserve Bank Bldg., V. W. Kraft, Purch. Agt., is in the market for two 100 hp. boilers for the Williams Collumn Co. plant on the Southern R.R.

Neb., Seward—The Evangelical Lutheran Seminary, c/o W. F. Gernandt, Archt., 701 Omaha Loan & Bldg. Assn. Bldg., Omaha, will receive bids until Apr. 19 for the construction of a 2 story, 61 x 169 ft. dormitory and a 32 x 32 ft. boiler room with chimney, 110 ft. high, including steam heating system, boilers, pumps, etc. Estimated cost $125,000 and $25,000 respectively.

N. Y., Afton—The Borden Condensed Milk Co. is in the market for ice machinery and milk plant equipment to replace that destroyed by fire.

N. Y., Batavia—G. Noak, florist, is in the market for boiler and heating plant equipment.

N. Y., Cohoes — The Cohoes Power & Light Corp., 45 North Mohawk St., plans the installation of a 10,000 hp. generating unit in its power house.

N. Y., Herring—The Power Corp. of New York, Northern New York Trust Co. Bldg., Watertown, plans to re-develop hydro-electric power of the St. Regis Paper Co., to double present 3,500 hp. installation, here. W. P. Creager, Ch. Engr.

N. Y., New York—The Mt. Sinai Hospital, 100th St. and 5th Ave., plans to build a 100 x 125 ft. nurses' school on 99th St. and 5th Ave. Estimated cost $1,500,000. Engineer or architect not announced.

New York — The Power Corp. of New York, Northern New York Trust Bldg., Watertown, will soon award the contract for hydro-electric development of Flat Rock site on Oswegatchie River to produce 4,000 hp. 24 hrs. daily. Work to include 65 ft. height x 800 ft. dam, power house and foundation for units. W. P. Creager, Ch. Engr.

New York—The Power Corp. of New York, Northern New York Trust Co. Bldg., Watertown, will soon award the contract for additional hydro-electric development at Northern New York Utilities plant at Effley Falls. Work to include enlargement of present power house to have 2,000 hp. generating unit, foundation changes, etc. P. Creager, Ch. Engr.

N. Y., Potsdam — The St. Lawrence Transmission Co. plans extensions and improvements to its lines, works and plants. Estimated cost $100,000.

N. Y., Utica—The Dairymen's League Co-operative Assn., H. A. Seick, 222 Lafayette St., Purch. Agt., is in the market for machinery for ice plant, capacity 20 ton per day, complete with synchronous motors.

N. C., Westfield—T. T. Joyce plans the construction of an electric light and power plant. Cost will exceed $25,000. Owner is in the market for equipment.

Ohio, Cleveland—The Broadhead-Garrett Co., 2835 East 51st St., J. C. Rash, Asst. Secy., plans to build a 1 and 2 story lumber mill and yard, including a 60 x 300 ft. warehouse, 40 x 40 ft. kiln building, planing mills, 40 x 50 ft. boiler house, also an office and garage building, on East 71st St. along tracks of Belt Line R.R. Estimated cost $150,000. Engineer or architect not selected.

Ohio, Cleveland — The Power Improvement Co., c/o G. E. Peterson, 15924 Euclid Ave., is receiving bids for the construction of a 5 story, 109 x 135 ft. sales, service and warehouse building, including steam heating system, on Cedar Ave. and Ashland Rd. Estimated cost $350,000. Private plans.

Ore., Hillsboro—The Ray-Maling Canning Co. is having plans prepared for the construction of a 2 story, 80 x 85 ft. factory. Estimated cost $50,000. C. F. Noak, Hillsboro, Engr. and Archt. The owner is in the market for a 50 hp. boiler, canning machinery, belting, etc.

Pa., Phila.—C. H. K. Curtis, Independent Sq., is having plans prepared for the construction of an 11 story, 230 x 360 ft. office building at 637 East Chestnut St. Estimated cost $5,000,000. H. Trumbauer, Land Title Bldg., Archt. Equipment detail not reported.

Pa., Phila. — A. H. Muller, Archt., 901 Walnut St., is preparing plans for the construction of a 4 story, 45 x 60 ft. apartment house with two 37 x 90 ft. wings, in the Oberbrook section. Estimated cost $1,000,000. Owner's name withheld. Equipment detail not reported.

Pa., Phila. — The Philadelphia Electric Co., 10th and Chestnut Sts., is having plans prepared and will soon receive bids for the construction of a 15 story office building on 9th and Sansom Sts. Estimated cost $2,000,000. J. T. Windrim, Commonwealth Bldg., Archt.

Pa., Tionesta—The Tionesta Silver Fox Ranch is in the market for cold storage and refrigeration machinery and equipment.

R. I. Saylesville (Pawtucket P. O.)—The Sayles Finishing Plants are having plans prepared for extensions to waste disposal plant, including cinder filters, dosing apparatus, pumps, etc. Estimated cost $80,000. Weston & Sampson, 44 Beacon St., Boston, Engrs.

S. C., Duncan—Lockwood, Greene & Co., Engrs., Piedmont Bldg., Charlotte, N. C., are receiving bids for the construction of a 4 story, 135 x 300 ft. cotton mill building; a 5 story, 75 x 100 ft. cotton store house building; a 1 and 2 story, 200 x 650 ft. bleachery; power house and pump room building; 300 houses for employees; 2,000 ton structural steel; various items of machinery and building equipment for the Pacific Mills, here.

Tenn., Johnson City—The Southern Refrigeration Co., H. W. Johnson, Mgr., is in the market for ice making machinery and equipment for plant to be built at Welch, W. Va.

Tenn., Nashville—The state legislature has appropriated $8,000 for equipping ice plant at State Prison. L. W. Pope, Dir. Public Institutions.

Tex., Dallas—The Chain Stores Co., 386 Bway., New York, K. T. Barnaby, Pres., McNeny & McNeny, Praetorian Bldg., Dallas, Local Agts., plans to build a 12 story, 108 x 200 ft. office building on Elm and St. Paul Sts., here. Estimated cost $1,000,000. Engineer or Architect not announced.

Tex., Dallas — G. C. Worthington, 1204 Dallas County Bank Bldg., contractor and builder, is in the market for a 12 x 14 engine, 16 x 54 boiler and a 42 in. fan and blowpipe.

Va., Richmond—The city, W. E. Trafford, Dir. Public Utilities, will receive bids until Apr. 18 for six electrically driven centrifugal pumps and a 30,000,000 gal. filter.

Va., Richmond—The Manchester Board & Paper Co. is in the market for a 150 hp. boiler.

Wash., Seattle — The Farmers Public Market Co., Carter, MacDonald & Miller, Agts., 208 Columbia St., plans to build a 2 story market building with refrigeration plant on 7th and Westlake Sts. Estimated cost $250,000.

W. Va., Charleston—The Kanawha Valley Bank, J. Q. Dickenson, Pres., is having plans prepared for the construction of a 19 story, 100 x 120 ft. bank and office building on Kanawha St. Estimated cost $1,500,000. A. C. Bossom, 680 5th Ave., New York, Archt. Equipment detail not reported.

W. Va., Sisterville—Chadderdon & Bradley are in the market for ice making machinery and equipment.

Wis., Green Bay—H. Dietsch, 520 Cedar St. (dairy products), is in the market for refrigeration machinery, power churn, separator, belting and shafting.

Wis., Hartford — The city, W. Radtke, City Clk., will receive bids until Apr. 17 for one 500 ft. air compressor.

Wis., Manitowoc—The Holy Family Hospital, c/o M. Generose, is having plans prepared for the construction of a 4 story, 50 x 248 ft. hospital and a 1 story power house. Estimated cost $300,000. E. Brielmaier & Sons Co., 432 Bway., Milwaukee, Archt.

Wis., Milwaukee — Cahill & Douglas, Engrs., 217 West Water St., is receiving bids on 2 generators, 125 and 625 kva., for the Pittsburgh Plate Glass Co., 213 Lake St.

Wis., Milwaukee — The Comn. of Pub. Wks. received bids for the construction of 130 x 240 ft. Riverside pumping station at the foot of Chambers St. from P. Riesens Sons, 1018 Humboldt Ave., $434,791; H. Damischefsky, 1484 Humboldt Ave., $444,910; W. W. Orflein, 86 Michigan St., $460,000.

Wis., Neenah—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, is receiving bids on a 1,000 kva. engine turbine unit, for the power plant of the Valley Paper Mills, 145 West Wisconsin St.

Wis., Plymouth—The Phoenix Cheese Co., L. A. Harbach, Mgr., is in the market for a 30 ton ice machine and refrigerating machinery, power machinery including 300 hp. steam generating unit.

Wis., Port Wing—The Northern Wis. Hydro Electric Power Co., T. N. Okushom, Mgr., is having plans prepared for the construction of a 60 x 90 ft. power plant with 500 hp. capacity and a power dam with a 42 ft. head on Iron River. Private plans. Electric power machinery will be required.

Wis., Stoughton—The Bd. Water Comns., S. B. Snyder, Supt., are having plans prepared for the construction of a deep well pumping unit with 1,000 g.p.m. capacity for city water supply.

Ont., Campbellford—The Hydro-Electric Power Comn., 190 University Ave., Toronto, has had preliminary estimates made for developing about 10,000 hp. at Dam 8, including power house, turbines, generators, switches, transformers, etc., on the Trent river, near here. Estimated cost $1,066,408. F. A. Gaby, c/o owner, Engr.

Ont., Lansing—The Twp. of North York, c/o H. D. Goode, Lansing, will receive separate bids until Apr. 14 for constructing pumphouse, filter house, plant and concrete dam; supplying and installing filter equipment; supplying pumping machinery consisting of electrically driven, 3 stage, centrigual pumps, etc., in connection with waterworks improvement. Estimated cost $125,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs. Noted Feb. 27.

Ont., Port Arthur—The Hydro-Electric Power Comn., 190 University Ave., Toronto, plans to install a 12,500 hp. unit in its plant, on the Nipigon River at Cameron Falls, including head 78 ft. vertical turbine directly connected to generator, 120 r.p.m., 10,600 kva., 12,000 volt, 3 phase, 60 cycle; circuit breakers; step up transformers. Estimated cost $1,500,000. F. A. Gaby, c/o owner, Engr.

Ont., Port Stanley—The Hydro-Electric Power Comn., 190 University Ave., Toronto, A. Beck, Chn., plans to build a steam power plant, 1,000,000 hp. capacity, here. F. A. Gaby, c/o owner, Ch. Engr.

Ont., Toronto—The Toronto Hydro-Electric System, Yonge and Shuter Sts., will construct extensions and improvements to its lighting and power system, including poles, transformers, conduit, wire, cable, switches, etc. Estimated cost $2,000,000.

Que., Rimouski—The Lower St. Lawrence Power Co., J. A. Brillant, Pres., is having plans prepared and will receive bids in May for the development of water power on the Metis River, including a transmission line 80 miles from Mantane to Princeville and a generating station at Princeville. Complete development and station equipment will be required. Noted Mar. 27.

Sask., Yorkton—The city plans the construction of a power plant. Estimated cost $100,000.

CONTRACTS AWARDED

Calif., San Pedro — The Pacific Coast Borax Co. awarded the contract for the construction of a 3 story factory, also a 1 and 2 story machine shop and boiler house to the Davidson Constr. Co., 1445 East 16th St., Los Angeles. Estimated cost $415,000. Noted Feb. 27.

Calif., Santa Rosa—The Natl. Ice & Cold Storage Co., Postal Telegraph Bldg., San Francisco, awarded the contract for the construction of an addition to its ice plant here to increase capacity to 60 ton, to E. Hildebrand, Santa Rosa. Estimated cost $50,000. Noted Jan. 23.

Conn., New Haven—The Connecticut Co., 127 Church St., awarded the contract for the construction of a 1 story, 36 x 72 ft. addition to its power plant on Grand Ave. to the Sperry Eng. Co., 136 Chapel St. Estimated cost $40,000. Noted Dec. 7.

Fla., Avon Park—The First Trust Co., the Verona Investment Co. and S. P. Durrance awarded the contract for the construction of a 100 x 200 ft. cold storage, office, store and theatre building, including the installation of cold storage equipment, vaults, etc., to W. J. Hein, Avon Park. Estimated cost $50,000.

Fla., St. Petersburg — S. Lund & Son awarded the contract for the construction of an 8 story hotel to contain 200 rooms, on 1st Ave. and Bay Shore Dr. to G. A. Miller, Stovell-Nelson Bldg., Tampa. Estimated cost $750,000. Equipment detail not reported.

Ind., Fort Wayne—The Masonic Temple Bldg. Co. awarded the contract for the construction of a 10 story, 90 x 130 ft. masonic temple to W. H. Sheets, Utility Bldg., Cleveland, O. Estimated cost $1,000,000. Steam heating system will be installed. Noted Dec. 12.

Ia., Cedar Rapids—The Disbrow Sash & Door Co., 7th Ave. and South 1st St., awarded the contract for the construction of a 55 x 126 ft. warehouse, a 51 x 100 ft. factory, a 40 x 43 ft. office building and a 30 x 50 ft. boiler house on Oakland Ave. to Loomis Bros., 326 3rd Ave., Cedar Rapids. Estimated cost $75,000.

N. H., Penacook (Concord P. O.)—The Dustin Island Woolen Mills, awarded the contract for the construction of additions to its factory, consisting of a 4 story, 55 x 80 ft. addition to its main building, 2 story, 35 x 120 ft. dyehouse, and a 1 story 40 x 65 ft. boiler plant, including steam heating and ventilating systems, to L. H. Shattuck, Inc., 208 Granite St., Manchester. Estimated cost $100,000.

N. Y., New York—The H. W. Johns-Manville Co., Inc., Madison Ave. and 41st St., awarded the contract for the construction of a 16 story addition to office building to W. Crawford, 7 East 42nd St. Equipment not reported. Noted Jan. 16.

N. Y., New York—The Lion Brewery of New York City, Columbus Ave. and 108th St., awarded the contract for the construction of an ice plant on Ludlow and Whitlock Aves., to Cunningham & Foley, Inc., 219 West 116th St. Estimated cost $400,000. The owner is in the market for ice making machinery.

N. Y., Watertown — The Northern New York Utilities Co., Inc., 58 Public Sq., P. Young, Mgr. Gas Dept., awarded the contract for the construction of two vertical retorts, 800,000 cu.ft. capacity, also for the remodeling of retort house at its plant in Engine St. to the West Gas Improvement Co., Inc., 150 Nassau St., New York. Estimated cost $200,000.

Pa., Chester — The G. C. Hetzel Co., Front and Broomall St., manufacturer of textiles, awarded the contract for a 1 story, 100 x 120 ft. mill and power house, also alterations to plant to W. Provost, Chester. Estimated cost $30,000. Generators, 50 and 210 kva. will be installed. The owner is in the market for additional looms, 150 motors and accessories.

Pa., Pittsburgh—The Bd. Educ., Fulton Bldg., awarded the contract for heating and ventilating in the proposed addition to high school on Margaretta and Beaty Sts. to Ryan Heating Co., 53 Tunnel St., $90,652; fans, Hersh Bros. Co., Federal Reserve Bldg., $2,886; boilers, Oil City Boiler Works, 1112 House Bldg.; motors, Wagner Electric Co., 530 Fernando St., $1,020. This corrects report in Mar. 13th issue.

Pa., Springdale—The West Penn Power Co., West Penn Bldg., Pittsburgh, awarded the contract for the construction of a 200 x 200 ft. addition to its power plant, here, to Sanderson & Porter, Engrs., 52 William St., New York. Estimated cost $6,000,000.

Wis., Two Rivers—The Aluminum Goods Mfg. Co., 15th and Franklin Sts., Manitowoc, awarded the contract for the construction of a boiler house here to W. W. Oeflein, 86 Michigan St., Milwaukee. Estimated cost $40,000. Boilers and coal hoppers will be installed.